Neural Substrates of Decision-Making in Economic Games

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Neural Substrates of Decision-Making in Economic Games

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Abstract

In economic experiments decisions often differ from game-theoretic predictions. Why are people generous in one-shot ultimatum games with strangers? Is there a benefit to generosity toward strangers? Research on the neural substrates of decisions suggests that some choices are hormone-dependent. By artificially stimulating subjects with neuroactive hormones, we can identify which hormones and brain regions participate in decision-making, to what degree and in what direction. Can a hormone make a person generous while another stingy? In this paper, two laboratory experiments are described using the hormones oxytocin (OT) and arginine vasopressin (AVP). Concentrations of these hormones in the brain continuously change in response to external stimuli. OT enhances trust (Michael Kosfeld *et al.* 2005b), reduce fear from strangers (C. Sue Carter 1998), and has anti-anxiety effects (Kerstin Uvnäs-Moberg, Maria Peterson 2005). AVP enhances attachment and bonding with kin in monogamous male mammals (Jennifer N. Ferguson *et al.* 2002) and increases reactive aggression (C. Sue Carter 2007). Dysfunctions of OT and/or AVP reception have been associated with autism (Miranda M. Lim *et al.* 2005).

In *Chapter One* I review past experiments with the ultimatum (UG) and dictator (DG) games and visit some of the major results in the literature. In *Chapter Two* I present the results of my laboratory experiment where I examine why people are generous in one-shot economic games with strangers. I hypothesize that oxytocin would enhance generosity in the UG. Players in the OT group were much more generous than those in the placebo—OT offers in the UG were 80% higher than offers on placebo. Enhanced generosity was not due to altruism as there was no effect on DG offers. This implies that other-regarding preferences are at play in the amount of money sent but only in a reciprocal context. The third chapter presents an experiment on punishment. I hypothesized that AVP would increase rejections and stinginess in the UG and TG. Results show that AVP affects rejections and stinginess in small groups but not in large ones. *Chapter Four* contains the summary of future research suggestions.

Neural Substrates of Decision-Making in Economic Games

By

Angela A. Stanton

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Approved by:

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We, the undersigned, certify that we have read this dissertation of Angela A. Stanton and approve it as adequate in scope and quality for the degree of Doctor of Philosophy.

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Introduction

Some of the limitations of the *Homo economicus* models in game-theory are effectively illustrated by robust empirical findings from games, such as the ultimatum game, dictator game, trust game, prisoners' dilemma, and public goods games. In lab experiments, game-theoretic equilibrium outcomes are typically not achieved by the participants. Robust experimental research results suggest that there are many factors included in human decision-making that are not included in the predicted game-theoretic equilibrium of decision-making (Joseph Patrick Henrich *et al.* 2001). Economics and game theory are based on the assumption that people can predict the actions of others; backward induction, iterated eliminations, and the Nash Equilibrium (NE) require a system of beliefs about the decisions of others. These assumptions are based on people's understanding other people's motives and beliefs (Tania Singer, Ernst Fehr 2005). This dissertation focuses on understanding two motives, generosity and stinginess, in the play of two economic games: ultimatum game (UG) and dictator game (DG) in laboratory environment under the influence of two naturally occurring hormone neuropeptides, oxytocin (OT) and arginine vasopressin (AVP), which are administered to half of the subjects, leaving the other half on placebo.

In each game two anonymous subjects play one-shot games with their show-up fee, which they are dividing between themselves in some manner. The purpose and the strategy of the two games are different. In the DG, decision-maker1 (DM1) receives $10 and is told that he may send any part of that to an anonymous person in the room (DM2). DM1 may decide to send no money at all and DM2 must accept that decision. There is no further exchange, the game is over. Sub-game perfect Nash Equilibrium (SGPNE) suggests that DM1 earns $10 and DM2 $0, but in laboratory experiments the average amount sent is between $1.50 and $5 dependent upon how (blind, double-blind, known identity) and where (what country) the game is played, with the mean offers of 20% of the stash, and around 20% of the subjects send the NE of $0 (various studies summarized by (Colin Camerer 2003) pages 57-58). The UG incorporates an additional step: DM2 may reject DM1's offer, in which case neither of them earns any money. Thus, the strategy here for DM1 is to allocate "just enough" money to DM2 to have the offer accepted, in which case they both earn the amount agreed to. The Sub-Game Perfect NE in the UG is $9 to DM1 and $1 to DM2 but in laboratory experiments this is rarely achieved. Offers range between $3 or $4 and offers smaller than $3 are rejected by half of the participants; about 75% of the subjects send an even split (Werner Güth *et al.* 1982; Daniel Kahneman *et al.* 1986; Joseph Patrick Henrich *et al.* 2005; Colin F. Camerer, Richard H. Thaler 1995; Colin F. Camerer 2003; pages 50-55). In the UG, DM1 needs to have some understanding of what is an acceptable offer so that DM2 would accept.

It is widely accepted that human social bonds are characterized by acts of altruism (Stephanie L. Brown, R. Michael Brown 2005;Herbert Gintis *et al.* 2003;Herbert Gintis 2002). Humans are known to benefit others at a cost to themselves in a variety of way. Reciprocal altruism is a form of altruism in which the altruist is in direct exchange with the recipient of the benefit and is expecting a reciprocation for the help provided (Robert L. Trivers 1971). This type of altruism is found in the trust game (TG), in which DM1 can send any part of his lab-given endowment to DM2. The amount sent triples en route to DM2, who can choose to send any part of the triple-stash back. The SGPNE for DM1 is to send $0 to DM2 but in lab experiments, typically 40% of the money is sent to DM2s who send back about a third of the tripled amount (Colin Camerer 2003).

Another type of altruism, introduced by Richard Alexander, is indirect altruism (also called indirect reciprocity) (R. D. Alexander 1979). In indirect altruism there is no expectation of reciprocation from the person who receives the benefit but there is one from someone else in the society in the future. Indirect reciprocity involves reputation and status (Martin A. Nowak, Karl Sigmund 1998) (Martin A. Nowak, Karl Sigmund 2005) and so it provides weak support to one-shot anonymous games where reputation building is not possible. Nonetheless, in the UG, we find evidence of indirect reciprocity in generous offers and punishment of those whose offers are not generous enough. Vernon Smith suggested some people might just be "preprogrammed to engage naturally in acts of positive reciprocity" (page 11) (Vernon L. Smith 1998b). But this "preprogramming" does not provide an answer for "why" people make the type of other-regarding decisions they make. Finally, there is what we call pure altruism (direct altruism), in which people provide benefits to others without expectation of any future benefit to themselves. This type of altruism we find in the DG.

The UG decision might rest on different prosocial emotions from the DG, and if it does, it might be direct-reciprocity (reciprocal-altruism as per Trivers), except that here too, the games are one-shot and the individuals don't know and don't see each other. Yet as there is a direct response of the anonymous stranger by either accepting or rejecting the offer, there is a direct connection between the two players. The results of the experiments I conducted provide answers to these questions in *Chapter Two*. Rejection in the UG is also debated as one of two kinds. In one sense the rejection might be other-regarding because the rejection is costly to DM2 and it also punishes DM1 for sending an unfair offer (D. J-F. DeQuervain *et al.* 2004; John H. Kagel *et al.* 1996; Ernst Fehr, Simon Gachter 2002; Joseph Patrick Henrich *et al.* 2006). This is sometimes referred to as "second-order punishment" (Mizuho Shinada *et al.* 2004; Karthik Panchanathan, Robert Boyd 2004). In the other sense the rejection maybe purely self-regarding and is the result of spite and anger for not receiving what is considered to be fair. The results of the experiment presented in *Chapter Two* indicate which group may be right.

Results of reported laboratory experiments using economic games show that cooperation is a primary and integral part of human economic exchanges. Individuals form and maintain social bonds using sympathy and empathy and provide benefits to others through helping and generosity (Stephanie D. Preston, Frans B. M. de Waal 2002b; Joseph Patrick Henrich *et al.* 2005; Adam Smith 1892). Empathy provides the feeling or the imagination of how another person feels in response to a particular event and it helps in the understanding and predictions of others' thoughts and intentions; it is a robust process that underpins prosocial as well as antisocial behavior (Cameron Anderson, Dacher Keltner 2002; George Ainslie, Nick Haslam 2002). Empathy reflects on prosocial behaviors that help form attachment between people in a society, which often leads to generosity and altruism (Stephanie D. Preston, Frans B. M. de Waal 2002b). Generosity is part of a variety of prosocial emotions, such as altruism, reciprocity, kindness, fairness, or doing something good (Michael Lewis 2002; Margery Lucas, Laura Wagner 2005; Catherine C. Eckel, Philip J. Grossman 1998; Gary E. Bolton *et al.* 1998; Frank Fincham, Julian Barling 1978).

To see whether the decision of how much money is sent in the UG is self-regarding or other-regarding, specific hormones influencing the associated different behaviors may be used. My experiment used two common hormones that are always present to varying levels in the human brain, one of which is known to assist in forming attachments while the other often acting in the opposite direction (in animal studies). Recent research on the neural substrates of decision-making suggests that some decision-making is hormone dependent. By artificially stimulating human subjects with different levels of hormones that they already possess, it is possible to identify if those hormones participate in a particular decision-making and identify brain regions affecting decisions. OT is associated with prosocial behavior. It plays a central role in regulating positive social interactions, such as attachment and bonding and affects both social behavior and the mechanisms underlying social behavior (Karen L. Bales, C. Sue Carter 2002; R. Landgraf, I. D. Neumann 2004; D. Huber *et al.* 2005; Kerstin Uvnäs-Moberg 1998; Paul J. Zak, Ahlam Fakhar 2006; Paul J. Zak *et al.* 2005b; Paul J. Zak *et al.* 2004; C. Sue Carter 1998; Kristin M. Kramer *et al.* 2005; Alison B. Wismer Fries *et al.* 2005; James P. Curley, Eric B. Keverne 2005; Eric B. Keverne, James P. Curley 2004).

Experiments have shown that manipulating OT levels in the brain influences how subjects perceive their environment (Jan Born *et al.* 2002; Michael Kosfeld *et al.* 2005b). OT seems to permit humans to overcome their anxiety of dealing with strangers in social context (Kerstin

Uvnäs-Moberg 1998; Kerstin Uvnäs-Moberg, Maria Peterson 2005; Kerstin Uvnäs-Moberg *et al.* 2005). Research shows that OT crosses the blood-brain barrier after intranasal administration (Jan Born *et al.* 2002), providing a simple method for studying its affect on humans in a one-shot economic exchange with strangers in lab environment.

Humans can understand and predict the intentions, beliefs, and desires of others and have the capacity to share the feelings of others; this is referred to as empathy (Tania Singer, Ernst Fehr 2005;Jim Proctor 2005). Thus the neural processes underlying empathy are of interest in the understanding of prosocial behaviors because it is an important factor in one person's recognition of the other's need, which might render human emotions other-regarding, providing the motivational basis for other-regarding behavior (Tania Singer, Ernst Fehr 2005). Offering generous help is a component of empathy (Cameron Anderson, Dacher Keltner 2002;Michael Lewis 2002;Stephanie D. Preston, Frans B. M. de Waal 2002a). Increased OT levels may induce more empathy (Kerstin Uvnäs-Moberg, Maria Peterson 2005). OT is hypothesized to influence subjects to behave more generously in prosocial decision-making.

AVP has multiple, oftentimes conflicting, roles. AVP may enhance attachment and bonding with kin in monogamous males (aiding social recognition of conspecifics in animal experiments) (Jennifer N. Ferguson *et al.* 2002). AVP is also associated with aggressiveness with respect to kin protection and reactive aggression (C. Sue Carter 2007). Lack of OT, in some research, dysfunction of AVP receptors, have been associated with autism, a frequent human disorder with symptoms of socially withdrawn behavior (Miranda M. Lim *et al.* 2005; C. Sue Carter 2007). AVP also controls the resorption of water by the kidneys, regulates the osmotic content of blood, and at high doses increases blood pressure (WO Foye *et al.* 1995). Research also suggests that paradigms in which animals have to cope with intense stressor are controlled by both AVP and OT (Mario Engelmann *et al.* 1996).

In *Chapter One* I present a historical background of research with the UG and the DG; a synthesis of the findings and the methods used. *Chapter Two* and *Chapter Three* present the results of two experiments with the UG and DG using OT (*Chapter Two*) and AVP (*Chapter Three*). I provide a brief conclusion with summary of findings and recommendations for future research in *Chapter Four*.

Chapter One

Historical Background

Most neoclassical economic models assume an agent to be maximizing to obtain the highest possible well-being (based on the expected utility theory) given available information about opportunities with constraints that are both natural and institutional. This model has become known as the *Homo economicus* model. The self-regarding Nash equilibrium predicts that in the DG a *Homo economicus* will behave self-regarding and keep all of the money, $10 in this experiment, and send nothing to the an anonymous player-partner if the game is played only once and the subjects don't have the chance to learn about the actions of the other. Thus, if such agents receive "$10 in manna from experimental heaven and [are] asked whether they would like to share some of it with a stranger," many say they do (Colin F. Camerer, Richard H. Thaler 1995).

However, experiments with small manna, big manna, culturally diverse experiments—including indigenous people in tribes—face-to-face, blind, double-blind, and in general, experiments in any shape or form over the past twenty years provide robust evidence that in one-shot games people don't obey the rules of the NE. The question then becomes "why not" and "what rule *do* people obey?" To answer these questions from the perspective of past research, this introduction is set out to review literature that spans over two hundred years, starting with Darwin and Adam Smith, and ending with the most recent concepts and experimental findings. Experimental interference and mistaken concepts played a key role in our developing understanding and is highlighted when necessary to advance my thought.

I chose to use the UG and DG in my experiments because they help us gain more knowledge beyond a simple understanding of how people play these games. Social infrastructure, business operations, and institutions evolve uniquely to fit the particular culture of each specific society. Economic exchanges frequently involve cooperation, reciprocity, and trust that enable decision makers to plan, reduce risk, diversify food and income sources, and plan for both the short and long term. "Most anthropologists would hardly be surprised by a finding that cultural ideas about sharing and cooperation prevent participants in economics experiments from acting in their narrowly defined self-interest" (Michael Chibnik 2005; pages 201-206) but traditional economics has excluded hypotheses of other sciences in order to retain its simple and elegant models that seemed to work well—before experimental economics was born and pointed out that they actually do not work all that well and aren't nearly as simple as game theory posits.

Experimental results show that human economic activity is a function of the biological and cultural makeup of each individual. These games are often used as parts of economic experiments in laboratory settings with US and other Western university students as subjects. In recent past, they have been adapted to experiments in other cultures, such as a study in 15 small-scale societies (Joseph Patrick Henrich *et al.* 2005) and others in other parts of the world (Hessel Oosterbeek *et al.* 2004; Michael Gurven 2004; Swee-Hoon Chuah *et al.* 2005; Laura Schechter 2006).

While humans behave similarly across some cultures in that they often show other-regarding behavior, the degree to which they are other-regarding seems to be culture specific. Interestingly, in nearly all cultures, there are some individuals who are selfish and leave little for DM2 in the UG. However, in nearly all cases, such acts are punished by rejection. In Henrich et al.'s study, the Au and Gnau of Papua New Guinea rejected offers even above 50% of the stash. Rejecting such generous offers sounds unreasonable but it may have a cultural foundation that is not immediately obvious to an outsider. In some societies, like the Au and Gnau villages and throughout Melanesia, accepting gifts of any kind creates a strong obligation to reciprocate at some future time. Debts accumulate, and place the receiver in a "subordinate status… As a consequence, excessively large gifts, especially unsolicited ones, will frequently be refused" (Joseph Patrick Henrich *et al.* 2005; page 811).

Human Brain as an Economic Adaptive Mechanism

It has been suggested that evidence coming from neuroscience, the study of how the brain works, "cannot refute economic models because the latter make no assumptions and draw no conclusions about the physiology of the brain" (Faruk Gul, Wolfgang Pesendorfer 2005; page 2). In their opinion, thus, decision-making of an individual, though is conducted by the brain as part of a higher-order processing mechanism, is separate from the mechanism of how that decision is derived. While we certainly cannot separate the actions of the brain from the brain itself, what they suggested has some merit, once put differently. Perhaps they should have said that some economic models make no assumptions about the *environment* in which the agents make economic exchanges and that they do not make any assumption about the *context* in which those exchanges are made either. The problem has always been that of complexity because including all the factors that a real human uses to make a decision would unnecessarily clutter economic models and make their use impossible. However, if heuristics do not lead to the same result as the economic models of the same decision-task, we cannot say that the models we now have are complete. The trick is to find just how much information we must include about the environment and the context such that we can predict the correct economic behavior without making the mathematics impossible.

It is necessary to look at human economic exchanges with a view that includes the context in which the decisions are made. This necessitates our understanding of both the external environment in which exchanges take place and also the "internal" environment, the one within the brain, because forever changing levels of hormones encourage changing moods and desires that are not necessarily explainable by linear relationships, probability theory, unchanging order of preferences between goods, and global optimum of all possible options. Physiology is the study of *all* the biological functions of living organisms. Thus, if economics is the study of exchanges that living people make, then economics is the study of human physiology as it relates to those economic exchanges—this is neuroeconomics. The physiology of the brain cannot be disconnected from the functions of the brain any more than the economic exchanges of a person can be disconnected from thinking about those actions with the use of his or her brain. The human brain is the headquarters of human actions; humans with diseases or damage to their brain show us the different economic decisions the brain can make due to its internal environment. Let me visit the birth of the conflict in economic thought and why economists play games, such as the UG and the DG.

The Start of Adaptive Decision-Making

Adam Smith mentions sympathy (as "fellow-feeling"), passions and how preferences are born in the Theory of Moral Sentiments:

> Neither is it those circumstances only, which create pain or sorrow, that call forth our fellow-feeling. Whatever is the passion which arises from any object in the person principally concerned, an analogous emotion springs up, at the thought of his situation, in the breast of every attentive spectator (page 5, Adam Smith 1892)

The above passage is often quoted in literature as the leading "passion" statement of Smith together a disclaimer like "oh well, it is in the Moral Sentiments, after all." It is less often discussed that Smith refers to passion in his other book too:

> With regard to profusion, the principle which prompts to expence, is the passion for present enjoyment; which, though sometimes violent and very difficult to be restrained, is in general only momentary and occasional (pages 281-282, Adam Smith 1909).

In this passage, Smith indicates that people sometimes spend more than they intend to; e.g. their emotions carry them away from making purely economic decisions. Adam Smith understood that humans' utility functions might have immeasurable, thus non-maximizable, values as well.

Explorations of Decision-Making through UG and DG

The debate using these games is that human subjects don't appear to be consistent with the game theoretical predictions of choosing the optimum solution from the particular bundle; that is they are not choosing their equilibrium solution. Furthermore, there is significant variation in the way that they appear to be inconsistent, and this variation has shown to be age and culture specific.

Choosing an equilibrium bundle is considered to be a distinguishing mental process; decision-making based on emotions and gut-feelings were reserved for the naïve and underdeveloped. Ironically, it was found that

> …younger children behave more selfishly, but gradually behave more fair-mindedly [other-regarding] as they grow older, up to age 22 or so… An important exception is that about one third of autistic children and adults offer nothing in the UG (E. Hill, D. Sally 2004); …[they] behave, ironically, in accordance with the canonical model (Joseph Patrick Henrich *et al.* 2005; page 799).

As humans grow older, they typically change from self-regarding persons to become more other-regarding. Camerer and Thaler describe fairness too as a learnt manner (Colin F. Camerer, Richard H. Thaler 1995). Indeed, Murnighan and Saxon found that notions of fairness and sharing do not appear until past third grade (J. Murnighan, Keith & Michael S. Saxon 1998). In their experiment, the most income maximizing DM2s were kindergartners (J. Keith Murnighan, Michael Scott Saxon 1998).

Even non-human primates are capable of grasping the meaning of economic exchanges; non-human primates have been playing ultimatum and dictator games—albeit their researchers did not explicitly state such claim[1].

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[1] Brosnan, de Waal, and many others, tested for emotions and reasoning in non-human primates (Sarah F. Brosnan, Frans B. M. de Waal 2003; Sarah F. Brosnan, Frans B. M. de Waal 2004b; Sarah F. Brosnan, Frans B. M. de Waal 2002; Sarah F. Brosnan, Frans B. M. de Waal 2004c; Sarah F. Brosnan, Frans B. M. de Waal 2000; Sarah F. Brosnan, Frans B. M. de Waal 2004a; H Smith et al. 1998; Frans B. M. de Waal 1997). In their test of Capuchin monkey cooperation, Bosnan et al. formulated an experiment that reveals interesting similarity to humans playing UG and DG. They set up pairs of Capuchin monkeys in two cages separated by a small fence and trained them to trade work for food. Two see-through bowls were provided outside these cages. Sometimes they were filled with food for one Capuchin, sometimes for the other one, or for both. Brosnan's team attached weights to the levers so that cooperative pull was necessary; e.g., if the bowl for one Capuchin was empty but the bowl was filled for the other, the one with empty bowl had to help pull, else neither of them got any food—this is a similar composition to the UG. Not helping to pull equals rejection and both stay hungry. In particular, Brosnan and de Waal found that Capuchins would help pull more often in the cooperation trials if in the previous trial cooperation was achieved. In other words, experience with the playmate from previous social interactions (e.g. reputation) helped in the decision-making if a Capuchin was worthy of a helping pull to give her food. The expectation of reciprocity is strong in non-human primates.

Brosnan and de Waal found the rate of acceptance of Capuchins having to give a helping hand to be 39% (Sarah F. Brosnan, Frans B. M. de Waal 2000), somewhat lower than the acceptance rate of human-sharing in UG (close to 100% in the UG). In the same experiment, Brosnan and de Waal found that Capuchins share their food in what they called "facilitated taking," in which when only one Capuchin received food from the cooperative pull, she moved close to the separating fence, let food pieces fall to the floor, and allowed the other Capuchin to reach over and take it through the fence. This I find similar to the DG, in

Vernon Smith has studied market exchanges in his laboratory and suggested that people have both cooperative and non-cooperative skills and they use them according to the appropriate occasions (Vernon L. Smith 1998b;Vernon L. Smith 2003). He also suggested that humans use non-cooperative (self-regarding) methods when dealing in the impersonal markets, while they use the more cooperative (other-regarding) means when dealing with family, friends, and neighbors—a somewhat similar statement to the "calculative trust" theory of Oliver Williamson a few years earlier (Oliver E. Williamson 1993).

Sometimes a self-regarding agent may choose to pretend to be other-regarding in order to achieve a particular goal (Colin F. Camerer, Ernst Fehr 2006b), which complicates the deciphering of what experimental subjects actually really think when they make their decisions. It is not too difficult to envision that the use of modern technology, such as functional magnetic resonance imaging (fMRI), may be used to see who is faking and who is not based on activation of the particular brain region. Perhaps "faking" is a cultural norm that all people use in economic exchanges. If so, one would expect a cultural "standard" of faking and most people would be found to fake at about the same level[2].

Reciprocity – The Nice Guys

Adam Smith's statements about emotional decision-making were overlooked for many years. In neoclassical economic theories human behavior was simplified and reduced to contractual interactions between agents that traded goods based on highest probability, lowest cost, and rigid orderability of preferences. The transition back toward Adam Smith's emotional agent started with Dawkins, Axelrod, and Trivers in the mid to late 70's.

Richard Dawkins titled *Chapter 12* of his book "Nice Guys Finish First," (Richard Dawkins 1976; 1999 edition) which was his translation of the turn of events brought to light by Robert Axelrod in three competitions for a "best" Prisoners Dilemma (PD) game solution in evolutionary terms—meaning the one that provided the most stable solution (Robert Axelrod, William D. Hamilton 1981; Robert Axelrod, Douglas Dion 1988). The PD game is simple; two computer "characters" (paired subjects equivalent) receive two cards: "cooperate" and "defect." Four combinations exist: either both cooperate, both defect, or one cooperates and the other defects with an asymmetrical payoff structure. Dawkins discusses this game from an evolutionary perspective and quoted American biologist Garrett Hardin who said "nice guys finish last" in order to emphasize what may have been called "selfish genery" that is befit to be a member of the classical economics theories of self-regarding actors. In Darwinian sense, "a nice guy is an individual that assists other members of its species, at its own expense, to pass their genes on to the next generation. Nice guys, then, seem bound to decrease in numbers: niceness dies a Darwinian death" (Dawkins, page 10). The classical economic theory's self-regarding maximizing individuals thus suit the Darwinian evolutionary image. But in Axelrod's competition, actually the "nice guy" finished first!

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which DM1 receives all the money (food in the case of the Capuchin) and may decide to share some with someone in the room (this means giving in DG and allowing to take in Capuchin experiments). Note, however, that in the case of the Capuchins, each participating female knew each other whereas the experiments with humans are usually blind, multi-gender, and typically one-shot.

[2] Most studies that published their results in the evaluation whether the perception of fairness is enough report that, indeed, the perceived fairness payment (when the DM2 is uninformed of the true value of the money DM1 has to split), on average, is below the informed payment and the offer that is perceived to be fair is accepted. But no study to this date analyzed whether *everyone* fakes fairness when the opportunity arises or if only some of the people do. See (Colin F. Camerer, Richard H. Thaler 1995;Michael Mitzkewitz, Rosemarie Nagel 1993;John H. Kagel *et al.* 1996;Rachel T. A. Croson 1996) for further details.

Dawkins explains why this “nice guy” could survive evolution (in contrast of the “Darwinian death”), which conceptualizes what is to have become the UG. He introduces *Grudgers*, a group within a type of bird that helped each other in an altruistic way, but refused to help—bore a grudge against—individuals that had previously refused to help them. Grudgers came to dominate the population because they passed on more genes to future generations than either Suckers (who helped others indiscriminately, and were exploited) or Cheats (who tried to exploit everybody and ended up bringing each other down). The story of Grudgers illustrates an important general principle, which Robert Trivers called ‘reciprocal altruism’ (Dawkins, page 202).

Reciprocal altruism is discussed in economics but has been assumed to only be participant in kin groups; hence it was troubling to think that people acted altruistically in the UG with non-kin. However, the *Grudgers* tell us a different story about altruism; they tell us that the *Grudgers* ended up dominating the population. What this means is that behaving altruistically can change the population from cheaters and defeaters into cooperators within a few generations. Camerer et al. (Colin F. Camerer, Ernst Fehr 2006) and Fehr et al. (Ernst Fehr *et al.* 2000) introduce concepts that are akin to this population domination by the “nice guys.” These concepts suggest that individuals with sharing motive can turn individuals with non-sharing motive into sharing types. The tools are the proper identifications and use of “strategic complements” and “strategic substitutes,” albeit with one caveat: in Camerer et al., the transformation is strategic and temporary, whereas in the *Grudgers*, it becomes genetic and permanent, pending genetic mutations on the long run.

At this point little can be said about possible methods of changing an entire generation toward becoming more sharing types, particularly if we use our abilities to put on a new face as the environment necessitates it. Changing to become other-regarding, in the case of strategic complementarity, is not only temporary but also “fake.” This should present a serious problem in our understanding of human behavior because we cannot know for sure when the subjects play genuine and when opportunistic (strategic) or fake. However, a large share of strong reciprocators in the population can be part of an evolutionarily stable situation, suggesting that those who “fake it” might be forced to convert (Robert. Boyd *et al.* 2003;R. Sethi, E. Somanathan 2003;Samuel Bowles, Herbert Gintis 2006). Some of the questions I would like to ask are as follows: What are the modifiable elements that change the behavior of the people? Does what is prevalent today in our society (as far as experiments can tell) provide an evolutionary stable system (ESS)? For example, which provides ESS: genuine fairness or faking fairness or the mixture of the two? What are the underlying biological functions that drive us toward or away from an ESS? Can we modify these biological functions without destroying ESS?

Economic decision-making doesn’t happen in a vacuum. To see the decision-making environment, it is helpful to first look at what it takes to program economic decision-making into computers that mimic human decision-making in a risky environment. When Axelrod set up the model for the evolution of human cooperation, he listed several requirements for the simulation steps, of which two are described here: (1) *specification of an environment* in which the PD can be operated, and (2) specification of the *genetics* (history), including the way in which information on the emulated chromosome is translated into a strategy for the simulated individual (Robert Axelrod 1981). Axelrod wanted to develop a PD game that was based on survival mechanisms, not unlike that of Dawkins’ theories on the gene (Richard Dawkins 1976). Axelrod also showed that increasing the number of players increases the difficulty of maintaining cooperation, and that having one player defect after a number of cooperating periods, increases the likelihood of the population reaching a certain threshold at which defection dominates.

The UG and DG

The UG was introduced in 1963, (L. E. Fouraker, S. Siegel 1963), and first used as part of an economic experiment by Güth *et al.* to analyze bargaining behavior (Werner Güth *et al.* 1982). Güth and his team described that by game theory, the UG is considered to be a game of one person on each end where each person is playing a game alone. But this assessment is incorrect because "all that player *i* has to do is to make a choice which is good for himself" (page 368), and the same for player *j*. However, if player *i* chooses his best maximizing solution and passes little or nothing to player *j*, in the UG player *j* has veto rights. If *j* is unsatisfied with the share of the pie, he can reject the deal, thereby cancelling the deal for player *i* as well; they both end up empty handed. Thus the two players are playing dependently on one another.

Güth found that players gave more money to stranger than would have been predicted by to game theory. Even more surprisingly, the receiving players used their veto rights even when some money was given to them. In one experiment players played both roles, the role of the sender and the receiver. Güth compared the amount of what each player maximally offered as DM1 and what the same player would minimally have accepted as DM2. The inconsistency, Güth thought, was attributed to the players' knowledge that they will play both roles. "Knowing to be player1 in one game and player2 in another game might have caused some subjects to care for a fair bargaining result" (380).

With Axelrod and Güth's publications showing that something other than monetary utility-maximization was driving economic decision-making in the laboratory, many experiments commenced; some with mistaken concepts that gave confused results and were based on unsound theoretical principles. Binmore et al. set out to test this "anomalous" economic decision-making of the players in one-shot UG. They designed the experiment such that each person played both DM1 and DM2 roles repeatedly against the same individual (K. Binmore *et al.* 1985). What they found was identical to what Güth et al found in 1982 and they warned about the validity of Güth's statement against the predictive power of game theory in the one-shot games. In proof that Güth's comment was inappropriate, they played what they called one-shot games, which had two stages. In stage one the players played a standard UG with 100 pence (monetary unit) and divided it in any way. In the second stage, the same two subjects (in anonymity) were paired but with only 25 pence and DM2 made the first offer. Only the opening offer of DM2 was recorded and compared with the first stage game. Thus what Binmore et al., played were sequentially repeated games with learning effects rather than one-shot games. Neelin et al., in repeating Binmore's experiment with three-shot games, found that the results of the two-shot games did not hold in three-shot games (Janet Neelin *et al.* 1988).

Some experiments that claimed to prove that humans make their decisions based on the expected utility theory's axioms placed the experiment itself on the basis of the thenceforth assumed utility theory, and set out to look for the very thing it assumed. A classic example of this is Rubistein's UG experiment in 1982 (Ariel Rubistein 1982). This experiment he called an "ultimatum-type" game between two players. In the first step, DM1 proposes and if DM2 accepts the game ends with the payout. If DM2 does not accept, he may *make an offer* and the game goes on for *several rounds*, until DM2 accepts. The assumption is that both parties behave according the expected utility theory and that all the axioms are met. Clearly such bargaining shares little with one-shot games in which cooperation between anonymous strangers is the object of study. Another critical unrealistic assumption is that all players have complete information about the preferences of others. The game Rubinstein used was a sequential *centipede* game with full knowledge at each nod of the opponent's step. Thaler critiqued by writing "when a Recipient declines a positive offer, he signals that his utility function has non-monetary arguments" (Richard H. Thaler 1988; page 197).

Gneezy et al. had a very similar experiment to Rubistein in1982. They experimented with what they called a "reverse ultimatum game" with a variety of conditions, such as deadlines and the number of responders participating, in repeated games of 25 (Uri Gneezy *et al.* 2003). They hypothesized that the addition of a deadline would shift the sub-game perfect equilibrium prediction from one extreme to the other in terms of which bargainer is predicted to gain all but a fraction of the available money, which is did, showing that the person with the bargaining control power takes home more. In their game, if DM2 rejected the offer, DM1 was allowed to make *another offer*. They called the game a "reverse" ultimatum game because it was DM1 doing the bargaining until DM2 accepted. However, similarly to Rubinstein in 1982, Gneezy et al. also applied a centipede game, but in which update was actual rather than Bayesian; each player received specific answer rather than a risky social cue. Gneezy et al., found significant learning effects over the 25 game-periods and that no matter which way the game was set up, the majority of the proposers still offered "fair" amounts rather than the SGPNE.

Hoffman and Spitzer, while testing the Coase Theorem in two- and three-person bargains, ended up drawing a conclusion for one-shot games, like UG and DG, but the game had complex rules, and there was this ever-present arbitrator to implement the decision (Elizabeth Hoffman, Matthew L. Spitzer 1982). Harrison suggested that the reason why DM2s reject offers is that the opportunity cost of "misbehavior" in these experiments is small and thus the anomalies may not be anomalies at all but reflect a "theoretically consistent behavior under conditions where misbehavior is virtually costless"(Glenn W. Harrison 1992; page 1426). However, so long as the stakes are small for both gain and loss, if the players find any kind of behavior costless, then I would think that the reverse is also true: there cannot be any benefits to being upset about not receiving enough share of the pie. The showing of "feeling insulted" by rejecting the offer, however small the offer may be, shows that DM2s receive some non-monetary utility large enough.

The influence of stake-size has been heavily investigated. Dickinson suggested that bargainers take advantage of information asymmetries (David L. Dickinson 2000). He hypothesized that as the size of the pie gets arbitrarily large, DM2s will be less likely to reject a smaller offer since the monetary penalty for doing so grows increasingly large. He set up an experiment to test information asymmetry in action and the kindness theory (kindness theory is a function Rabin developed that he called "kindness function," which measures how kind one player is to another (Matthew Rabin 1993). Dickinson did so by changing the size of the available stash (from $1 to $15) and by telling only DM1 what DM2 did in the previous round and he played repeated games for five rounds but with different partners in each round. DM1s were given on "a piece of paper what [DM2] was offered, what the pie size was, and they were also told whether or not [DM2] accepted or rejected the offer" (David L. Dickinson 2000). Furthermore, he was comparing if stake-size changed the rejection percentage. He reports his results as having found statistically significant means but the significance powers are rather mild (p-range 0.08 to 0.43, with one exception, the $7 stash was significantly different at $p = 0.02$ – page 165). However, in my view, the DM1's offer was not a response for the changing size of the pie but for the history of previous response by DM2, in other words, Dickinson tested the effect of *reputation* on UG transactions; he replaced ambiguity with a known probability distribution. Yet even then, his results were rather mild.

Cameron ran a field experiment in Indonesia in 1994 in which she raised the stakes to represent substantial earnings (for example, she offered $100 stake where the per capita gross domestic product was US$670) and she found that stake size had no effect on the percentage of money DM1 sent to DM2, or the percent that DM2 rejected; as found Carpenter et al., in their experiment where they tested both the UG and the DG (Jeffrey Carpenter *et al.* 2005; Lisa A. Cameron 1999). However, Cameron found that in imaginary (hypothetical) games, DM2s were much more likely to reject than in real games (Lisa A. Cameron 1999).

Eckel and Grossman recruited two groups of players: volunteer subjects in the usual way and pseudo-volunteer subjects (class-time students), all participating in a DG experiment with a *charity* as the recipient (Catherine C. Eckel, Philip J. Grossman 2000). The experiment was meant to test for social signal differences between volunteers and pseudo-volunteers in the typical economic exchange scenario using DG. The unintended interference was provided by the subjects being asked if they would be willing to participate "voluntarily" in a game (asked in class by the authors, who were professors in these classes) – henceforth called the "pseudo volunteers," the charity that was chosen by the authors (professor's favorite?), and by the pseudo-volunteers' knowledge that they have the "option" to donate to the professor's charity (Catherine C. Eckel, Philip J. Grossman 2000). As there is no risk or ambiguity involved in offering a donation to a charity, no applicable social signal was exchanged, only personal preference, and because the professor's image was hovering in the pseudo-volunteers' mind when making their decisions, they showed skewed preference toward "sharing". Eckel and Grossman thus found that volunteer subjects (those with no connection to the class, and hence receiving grade from faculty) were significantly more likely to offer zero to the charity than pseudo-volunteers; almost 29% of the pseudo-volunteer gave *everything* to the charity, while only 5% of the true volunteers did.

Even as late as 2005, we still find misunderstandings about human nature and human behavior in economic experiments. For example, Bardsley noted that people don't seem to make anonymous donations to strangers and decided to set up an experiment to test whether DG truly measure social preferences or if they measure something else (Nicholas Bardsley 2005). He hypothesized that if giving money was equivalent to *taking money* (as it is true in mathematics), then the game reflected true social preference. He wanted to measure the difference between what players would offer to give and what they would take. However, he did not find any difference because subjects, knowing that in one experiment they will give and in the other take, did not offer much in the first place in the giving part. Furthermore, in one version of the game the subjects had to choose between giving some positive amounts (from £0 - £4) or take £2 from the show-up fee earned by the opposing players—and results suggest that many did take but not all. In order to get stronger results, he simulated 10,000 experiments and using nonparametric techniques, he was able then top reject the null hypothesis at 5% level. Hence, what Bardsley actually tested was a player taking the endowment from one player (negative) versus a player giving something from his endowment by choice (positive) to the other.

However, giving is an altruistic act while taking is a *punishing* act. Adding and subtracting in human terms have strikingly different utilities associated with them; one provides reward and the other punishes in terms of endowment. Thaler showed that an item of endowed value is greater than the value of the same item not yet owned (R. Thaler 1980).

My final example of mistaken views is Rustichini's comment, who suggests that

> …the task of an economist is to establish useful predictions on which human behavior will follow given certain incentives, preferences, and feasibility constraints. This set of parameters, that is available to the economist analyzing the situation, defines the input, and the behavior is the output (Aldo Rustichini 2005; page 203).

Rustichini is missing the most important element in the definition of the input and the output. Where is the giant processing machine, the brain? Rustichini suggests that inputs are given by external conditions (incentives and constraints) and internal ones (preferences) that combined provide the variables for processing, of which the *output* becomes the human *behavior*. Put differently, if Rustichini's comments were true, similarly to any factory machinery or computer used as processors, so long as the inputs are the same, one would predictably always get the same output. This suggests that the *processor* does not add additional input variables, which is certainly true in the case of computers. However, each person has a very unique processor sitting atop his or her neck and each of these processors provides additional inputs (hormones) into the model based on a mixture of physiological constraints. In fact, this is precisely what laboratory experiments with economic games are trying to capture.

The researchers provide the same instructions and the same money to each participant—thus the controllable external variables are the same. Not only do experimenters want to see the end result (the outcome) of how much money is exchanging hands, but the behavioral constraints as well by analyzing blood hormonal levels or imaging the brain at the time of decision-making or adding neuropeptides to analyze how modified internal environment of the individual affects how much money is exchanging hands. In the case of humans, it is the behavior and not the input that modifies the output. If the brain did not provide input, how would adding neuropeptides modify the outcome? Yet adding neuropeptides does modify the outcome! See a great study about nasally administering OT into human subjects and what that does to their behavior in terms of modifying the output they offer (Michael Kosfeld *et al.* 2005a) and also see the next chapter in which I use OT to induce a more generous behavior in the UG.

Great Experiments

There have been some truly ingenious experiments as well as there were lots of oppositions to the games and experimenting techniques. Vernon Smith suggested that "subjects *experience* the choices of others and then choose based on what they have learned to accept" (Vernon L. Smith 1998b; page 110, emphasis added). But not all experiments offer the chance of experiencing the decisions of others. In particular, experiments that want to learn the influence of hormones do not provide feedback because it would contaminate the results by measuring reactive emotions rather than the affect of the neuropeptide itself. Smith argued that the experimental procedures themselves constitute unintended contaminants. He further suggested that

> …the idea that one should randomize effects that are not controlled comes from biology, where you randomize treatments among plots of land to prevent differences in soil quality from being attributed accidentally to the treatments. But human subjects are not plots of land, and the method of assignment may not have a neutral effect on behavior… results call into question the interpretation of data from the large literature in bilateral bargaining that is characterized by a first-mover, or other asymmetric advantage, randomly assigned… the question is whether inducing fair behavior is the appropriate way to frame the test of a bargaining theory that assumes self-interested agents whose interests conflict, as with management and labor. Now, if one were to replicate all the asymmetric bargaining experiments, assigning privileged rights only to those who earned them, and still observe fair outcomes, then this would call into question the relevance of the theory" (Vernon L. Smith 1998a; 112-113).

Smith makes a good point. As the reader will see in chapter 3, I describe such possible contamination by randomizing the order in which the games were played. It is well documented that some games, the trust game in particular, makes the subjects release OT (Paul J. Zak *et al.* 2004). Such OT release can override the effects of other hormones—in this case AVP—cancelling out the desired effect.

Schotter et al. designed an experiment to test what Smith suggested: mimic a "true" market under survival pressures and see if agents still defy the theory (Andrew Schotter *et al.* 1996). His team introduced property rights in two-stage-survival UG and DG, in which proposers were competing with each other in offering higher amounts to the same one responder. Whoever was able to have his offer accepted, entered stage two as "property right owner." As property owners, the money they kept for themselves in the second game (second stage) was higher; "demand behavior changes substantially as we move from the one-stage to the two-stage experiments" and DM2s rejected less often the smaller amounts offered in the second stage (Schotter et al., 1996, page 44).

To address the first-mover-advantage question, Weber et al. set up an experiment to see if first movers would demand different dollar amount from when the same players moved second (Roberto A Weber *et al.* 2004). They found that minimal acceptable offers (MinAccept) of DM2s became lower when they knew that they were going to move second, and were higher when they knew that they were first-movers. They suggested that the timing result points to an interpretation on fairness that is incomplete. If only distaste for unfairness drives the response of DM2, their minimum acceptable offer amount should not change based on the knowledge of who moves first. Within the fairness framework, the answer they suggest is that a low offer appears to be fairer when a person is DM1 and moves first than when that same player is DM2 and moves second. But this answer suggests that fairness is based on who has access to exercise advantage (Weber, page 40).

Kahneman et al. wanted to get a better understanding of how consumers react to the model of profit-seeking firms by considering the newly discovered preferences that people have for being treated fairly (Daniel Kahneman *et al.* 1986). They set up an experiment in which two individuals played the DG. The dictator was called "fair," if he offered half of the play-money or "unfair" if he took more than half. A third individual then had to choose with whom she would split a certain dollar amount (knowing the history of previous exchanges). Would she split a larger amount with an unfair player or a smaller amount with a fair player? The majority of the third players chose to split the smaller amount in order to share with the fair player, albeit at a cost to themselves.

Aumann suggested that even though people reject in UG because they are insulted, the models still consider this insult exogenous (Robert J. Aumann 1986). He recalled Axelrod et al.'s experiment with the PD game and how it is usually "a crazy type, that wins out – takes over the game, so to speak… there is only one crazy type, who always plays tit-for-tat, no matter what the other player does; and it turns out that the rational type must imitate the crazy type, he must also play tit-for-tat." Axelrod's team already had a theory why crazy types win (Robert Axelrod, William D. Hamilton 1981; Robert Axelrod 1981; Robert Axelrod, Douglas Dion 1988). But new theories have emerged providing different theories about who these "crazy types" are and why they win. Fehr and Tyran (Ernst Fehr, Jean-Robert Tyran 2005), and Camerer and Fehr (Colin F. Camerer, Ernst Fehr 2006) suggested that "strategic complementarity"[3] is participating in these games, which means that it takes only a small number of individuals to play other-regarding before that may lead to large deviations from aggregate predictions of NE models, whereas under strategic substitutability[4] the opposite is true, a minority of self-regarding agents may suffice to generate aggregate outcomes consistent with the predictions of NE game-theoretical models.

The process of why Aumann's "crazy types win" is detailed by Camerer and Fehr as follows: what happens if a strong reciprocator faces a self-regarding player and both players know each other's preferences? [Note: there is a bit of a problem here with "knowing" the other person's preferences but I will let it go at this time for the sake of making a point]. In a simultaneous game, the existence of the self-regarding player will induce the reciprocator to behave non-cooperatively as well. If the exchange is structured sequentially, however, with the self-regarding player starting first, an exchange will take place because the self-regarding player knows that the reciprocating player will only respond to a reasonable offer (Colin F. Camerer, Ernst Fehr 2006a; page 47).

Preferences, Beliefs, and Environmental Factors

I would like to return to my note about knowing the preferences of others above in Camerer's and Fehr's explanation. Obviously they placed the framework of the "old" *Homo economicus* model as grounds for explaining a phenomenon that otherwise has no known answer (so far) in this literature review—the reader may suggest that telepathy may exists under these circumstance. Assume for a moment that you, the reader of this article, and I suddenly find ourselves engaged in playing a game of DG or UG, anonymously. Would I, under any circumstances, know your preferences without actually knowing you? Would you know mine? Certainly, I may postulate that given that you are reading my article, you and I share at least one thing in common: we both know what this article is about; this gives you some shared history of me. This may allow us to form beliefs about one another's expectation but those are

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[3] "I do as you do"

[4] "if you go right I go left"

just *beliefs* (some based on reputation) and *not* actual knowledge of preferences. In the lab where experiments are conducted, hundreds of students converge from the same university in a room to play the games. Obviously they share some beliefs—otherwise they would not be students in the same institution. In general every university lab experiment is biased by the homogeneity of the population from which a group of convenience is selected for experiments. Random selection must be ignored and the subjects are not independent because they all share at least two systemic bias: 1) same university and 2) they all are volunteers, which by definition distinguishes them from those who don't volunteer. However, as these errors are systemic across the board in all experiments, perhaps we all start from a plateau that is different from a study of true independent observations but since all laboratory experiments have them, this systemic error can be ignored.

"Cultural traits like values, ambitions, and lifestyles influence economic behavior and thereby economic conditions [see on this subject (Paul J. Zak, Stephen Knack 2001)]. Economic conditions exert selective pressure on the cultural traits" (Selten, page 90). "Mechanisms of cultural evolution are shaped by biological evolution and competitive processes involve learning and imitation" (Selten, pages 92, 101). Thus Selten also noticed the mimicking behavior necessary for successful societies. Henrich and team found in their experiments in 15 small-scale societies that there were distinct group-differences in notions of fairness (Joseph Patrick Henrich *et al.* 2005). They also found that the level of market integration of a society influences differences in notions of fairness and punishment. They found that the selfishness axiom accurately predicts DM2 behavior in some societies but not university students in lab experiment. They also found that few or none of the subjects in these small-scale societies offered zero in DG. They further write that "cultural evolution and its products have undoubtedly influenced the human genotype… The relationship between culture-gene coevolutionary theory and the preferences, beliefs, and constraints approach is straightforward, although rarely illuminated" (Henrich *et al.*, page 812).

Fairness in One-Shot Blinded Games?

The question of whether *fairness* drives the unexpected human behavior in UG was asked by many. *Fairness* is defined as sacrificing self-gains "to change the distribution of material outcomes among others, sometimes rewarding those who act prosocially and punishing those who do not" (Joseph Patrick Henrich *et al.* 2005; page 797). Forsythe et al. tested if the fairness hypothesis can explain the result of Güth's experiment (Robert Forsythe *et al.* 1994b; Robert Forsythe *et al.* 1994a). They hypothesized that if the results of the UG and the DG are the same, fairness is the explanation. However, as they did not find this to be the case, they concluded that fairness can only be one factor that determines the money offered by DM1 in UG. Nowak *et al*. developed an evolutionary approach to the UG (M. A. Nowak *et al.* 2000). They suggested that fairness will evolve if DM1 can obtain some information on what deals DM2 has accepted in the past, similarly to the hypothesis of Dickinson (David L. Dickinson 2000). They believed that the evolution of fairness, similarly to the evolution of cooperation, is linked to reputation and is driven by a mechanism that is similar to genetic evolutionary forces. Like Dawkins' *Grudgers,* future generations of individuals leave their offspring in proportion to their "total payoff," which in this case is "success rate," and each new generation only deals with those who have been accepted by DM2s in previous encounters. This process can readily lead to the evolution of fairness in repeated games where reputation matters. Why fairness evolves without explicit reputation, as is the case in one-shot blinded games, remains to be solved by those experiments that can measure emotional responses more directly, such as the two experiments that follow this chapter.

The dictator game by its nature removes incentives for strategic behavior. The assumption is that if players still act fairly in DGs, they must have a taste for fairness, which was introduced earlier as sacrificing self-gains in order to change the distribution of material outcomes among others to benefit those who act prosocially and punish those who do not (Michael P. Haselhuhn, Barbara A. Mellers 2005). Haselhuhn and Mellers modified the UG and DG such that DM1s are also asked to imagine the pleasure they would feel with each possible payoff—payments were paid according to the actual games and not based on the imagined possible payoffs. They were told to rank-order their preferences over all possible offers, and to draw inferences about the emotions DM2 might feel. Their statistics show that 25% of DM1s thought they did not derive pleasure from fairness, 65% some pleasure, and 10% significant pleasure (Michael P. Haselhuhn, Barbara A. Mellers 2005). They also found that preference-orders differed from pleasure-orders. Most DM1s made fair offers in the UG, but cooperation appeared to be strategic rather than emotional. However, there were 10% of DM1s who derived greater pleasure from fair payoffs than from larger payoffs (Michael P. Haselhuhn, Barbara A. Mellers 2005, page 29). In the DG, 55% of dictators derived no pleasure from fairness, and 15% felt significant pleasure from fairness. Those dictators who received pleasure from fairness, tended to make fair offers even when they had no strategic reason to do so.

Saad and Gill (Gad Saad, Tripat Gill 2001) and Eckel and Grossman (Catherine C. Eckel, Philip J. Grossman 1996b) found that in the UG, female allocators were more concerned about fairness when making offers than males, while males made more generous offers when pitted against a female than a male. White females made equal offers independently of the sex of the recipient. They also suggested an evolutionary explanation for fairness; "male allocators are altruistic towards female recipients and competitive with male recipients is construed as a manifestation of social rules, which evolve from the male predisposition to use resources for attracting mates" (Saad and Gill, page 171). Takahashi observed that there was a negative correlation between interpersonal trust and social stress-induced cortisol elevation in DM2s in UG under stress, indicating that subjects with high levels of interpersonal trust showed reduced social stress (Taiki Takahashi 2005). "Collectively, interpersonal trust might possibly enhance social cooperation via better social memory due to lowered acute social stress actions during a face-to-face social interaction, which would result in high levels of an economic growth" (Taiki Takahashi 2005; page 4).

Environmental Cues: Cultural Heuristics

I have frequently mentioned throughout this essay that players have beliefs rather than actual updates of the preferences of others. One clever experiment calls attention to cues that hang in the general environment without even our conscience observation. Blythe et al. set up an experiment that shows just how such social cues may enter into comprehension without the players' knowledge (Philip W. Blythe *et al.* 1999). Their goal was the opposite of what one may expect; they wanted to see if complex social cues can tell the story about the *intentions* of the individuals while playing certain games. The games were played by volunteers on the computer with imaginary little creatures. On screen two bugs: one blue and the other red. Each player played 6 types of games: red bug *plays* with blue bug, red bug *courts* blue bug, blue bug acts *being courted*, blue bug *courts* red bug and red acts *courted*, red bug *pursues* blue bug who is trying to *evade*, the same with bug color change, and lastly the two bugs are *fighting*. In each of these games, the human volunteer controlling the specific bug is given a list of "to do's" but otherwise "acts out" the feeling according to his or her best interpretation of what "courting" or "fighting" means. For example, to court, the bug "owner" volunteer was told to move the bug to court the other bug by interacting with it in any way that it might find interesting, exciting, or enticing. The owner of the courted bug was instructed to move the bug to show interest or disinterest, and to elicit further displays in any way desired (page 266).

Since the bugs were computer images, their movements could easily be digitized and recorded on a time-series model 3D graph—the bugs themselves were reduced to directionless dots. Blythe *et al.* averaged the motion images of the many trials and displayed the aggregate image of the six motion types. Next they invited new volunteers who were not familiar with the game and replayed in front of them only the time-correct motion graphs of dots (no bugs were seen). The job of the volunteers was to identify which type of the six the particular bug-aggregate-motions they were looking at. The uninitiated were able to predict the motion-intents of the bug on the screen with about 50% accuracy based on the graphs alone—random guessing is expected to be correct 18% of the time, so 50% is well above randomness. When Blyth's team removed one of the two bugs and showed, again, to uninitiated players, but this time the bug-aggregate-motions of only one of the two bugs, the recognition of the motion was reduced to approximately 30% but still did not disappear.

What this experiment clearly demonstrates is that social cues "in the air" can continuously reaffirm or modify a person's belief in the type of environment. In the laboratory, there is plenty of opportunity for receiving such social cues. One of them, I already mentioned, is that the volunteers come from the same institution. Another is that as they come for the experiments, they line up to provide their student identifications; sometimes the line is long and there is ample opportunity to look and feel who is in the crowd. Although once the UG or DG starts in the lab, the volunteers do not specifically know whom they play with, they certainly know the "average makeup" of the people in the room. They can, thus, estimate if they are in an environment where acting according to the rules of strategic complementarity or strategic substitutability would offer the highest payoff.

Reciprocity can be based on experience from the past by having repeated interaction but they can "also be based on the knowledge that the members of the interacting group are 'alike'" (Ernst Fehr, Bettina Rockenbach 2004). In an experiment by Gachter and Thoni, subjects were ranked with respect to their contribution in a one-shot PG game and then sorted into groups of individuals with similar ranks (S. Gachter, C. Thoni 2005). Cooperation in the "alike" groups of like-minded people was found to be significantly higher than in random group composition—supporting significantly that lab environment, which is made up of individuals that are members of an "alike" group, might provide economic choices that reflect the norms of that "in-group."

Framing and Machs

Hoffman et al. conducted several interesting experiments testing fairness with a variety of framing approaches. In their 1996 experiment, using DG, they tested the theory that framing might have a lot to do with the appearance of fairness in the game (Elizabeth Hoffman *et al.* 1996). In most cases at that time, the experiments were conducted under observation, rather than blindly from everyone, including the experimenters. They conducted their experiment double-blind and requested that the dictators place their offer to the recipient into an envelope, place the envelope in a box, from which the experimenters took them, counted the money and passed them on to the recipients. They found that "there was a pronounced tendency for those leaving no money to seal their envelope, and for those leaving positive amounts of money to not seal their envelopes." They concluded that other-regarding behavior varies with context based on opportunity costs (Elizabeth Hoffman *et al.* 1996). With respect to framing, they suggested that subjects bring their ongoing experience of the world with them into the laboratory, and the instructional language used can associate a subject's decision with past experience. For example, "suggesting that the task is to 'divide' the $10 may imply that the objective is to *share* the money with someone, who, though anonymous, is socially relatively near to the decision-maker" (Hoffman, 1996, page 655). Bolton et al. agrees with Hoffman et al., suggesting that in comparing their data with that of previous studies, they also find differences in the results of the games based on the differences in written directions (Gary E. Bolton *et al.* 1998; Elizabeth Hoffman *et al.* 1999).

Carpenter et al., had players fill out a personality scale called the *Mach* scale (first developed in (R. Christie, F. Geis 1970)), which consists of 20 statements drawn from Machiavelli's The Prince (Machs) to which subjects agree or disagree (Jeffrey Carpenter *et al.* 2005). Those who tend to agree with the statements are the high *Machs* and the others the low *Machs*. They included the *Mach* scale to control for "variations in predispositions toward engaging in manipulative behaviors." In previous work. H.-D. Meyer (1992) found evidence suggesting that high *Machs* accept low offers and reciprocate less (A. Gunnthorsdottir *et al.* 2002). Burks et al. found that high *Machs* were also less trusting, sending less and rejecting higher amounts (S. Burks *et al.* 2003). McCabe et al., however found that Christie and Geis's Machiavellianism scale (Mach-IV) is not a good predictive tool to measure the trust of subjects in the trust game (Kevin McCabe *et al.* 2002).

As there is substantial debate over why humans use costly punishment, Xiao and Houser tested experimentally if constraints on *emotion expression* would increase, decrease, or keep the same, the use of costly punishment (Erte Xiao, Daniel Houser 2005). They found that rejection of unfair offers was significantly less frequent when DM2s could convey their feelings to DM1s concurrently with their decisions. Their data supports the view that punishment might be used to express the negative emotions players feel when they are treated unfairly.

fMRI

Sanfey et al. noted that the magnitude of activation in the bilateral anterior insula, dorsolateral prefrontal cortex (DLPFC), and anterior cingulate cortex (ACC) (using fMRI) were significantly greater for unfair offers from human partners then from computer partners (A. G. Sanfey *et al.* 2003). They also found the magnitude of activation to be significantly greater in both sides of the insula for unfair offers from human partners than to both unfair offers from computer partners and low control offers. The insula is associated with the feeling of negative emotions. For example, Singer et al., found in an fMRI experiment that the insula is associated with the feeling of pain of a loved one (Tania Singer *et al.* 2004) and Wager et al., found that the insula is also able to partake in placebo-effects of suggestions of investigation (Tor D. Wager *et al.* 2004). They suggest that these activations were not solely a function of the amount of money offered but rather they were sensitive to the context, the *perceived* unfair treatment from another human. Regions of "bilateral anterior insula demonstrated sensitivity to the degree of unfairness of an offer, exhibiting significantly greater activation for a \$9:\$1 offer than an \$8:\$2 offer from a human partner" (A. G. Sanfey et al. 2003; page 1756).

Sanfey et al.'s findings are in conflict with the results of Rilling et al., (James K. Rilling *et al.* 2004) who used fMRI for experimenting with UG and PD games, using human and computer partners. In Rilling's team's experiments of UG, the scanned participants were always in the role of DM2. Unfair offers by humans were rejected at a significantly higher rate than the same offers by computers, as was also found by Sanfey et al. in 2003 (A. G. Sanfey *et al.* 2003). However, Rilling et al. found that while playing the with computer partners, they got different results for playing UG or prisoner's dilemma (PD). While playing the UG, computer partners did not activate the same regions in the brain as did playing with real people. In other words, the scanned participants' brain actively distinguished between playing with a computer or a person. Each participant in the scanner knew the identity of the other player, even when the other player was a computer—there was no deception. In spite of knowing that the scanned partner was playing against a computer, when playing the PD game, playing with computer partners elicited the same brain activation in the scanned DM2 than when playing with a real human partner.

Put differently, in PD game, the brain is not able to distinguish between playing against a computer or a person, even when all facts are clearly stated to the scanned participant. Several areas, including right dorsolateral prefrontal cortex and right parietal lobe were activated in both cases. Event-related plots for both of these regions of interests (ROIs) reveal an increase in activation in response to the partner's face (could be computer "face" in case of a computerized partner) that remain elevated until the game outcome is revealed, at which time there is a secondary increase—in other words, when image is seen, there is an expectation until the offer is revealed. Rilling et al. found that there was a notable discrepancy between the UG and the PD games in the ability of computer partners to elicit activation in areas also activated by human partners. They suggest that this difference may relate to the varying "responsiveness" of the two computer strategies. In the UG game, the computer did not respond to participant choices; it simply made the participant an offer. But in the PD game, the computer responded to a choice by the participant and gave the impression that the computer's decision was contingent on the human participant's choice. Mutual cooperation and the punishment of defectors activate reward related neural circuits, suggesting that evolution has endowed humans with mechanisms to render altruistic behavior psychologically and physiologically rewarding (Ernst Fehr, Bettina Rockenbach 2004).

The results of recent years' experiences provide support for the hypothesis that neural representations of emotional states guide human decision-making. Sanfey found that the anterior insula scales *monotonically* to the degree of unfairness felt by the participant, reflecting the emotional response to the offer (A. G. Sanfey *et al.* 2003). Unfair offers were also associated with increased activity in the anterior cingulate cortex. Areas of anterior insula—maybe representing the emotional reaction to unfairness— and the dorsolateral prefrontal cortex (DLPFC)—maybe representing the cognitive part for earning money—represent areas for decision-making in UG. Other recent neuroeconomics studies that scan subjects' brains while they are making decisions in interactive economic experiments also provide interesting results on the neural foundations of reciprocity (K. McCabe *et al.* 2001; J. K. Rilling *et al.* 2002; R. Adolphs 2003; A. G. Sanfey *et al.* 2003; D. J-F. DeQuervain *et al.* 2004). These studies support the hypothesis that neural representations of emotional states guide human decision-making and that subjects derive specific rewards from mutual cooperation and the punishment of norm violators.

Learning effects form expectation and adaptation in brain cells. For example, drug addiction is a form of learning effect, called "incentive learning," where if the neurons' expectation of the upcoming drug is not met, withdrawal follows. During "withdrawal, rats with previous experience of heroin in withdrawal initiated drug-seeking with a shorter latency, and showed more completed cycles of drug-seeking compared to either saline controls or control groups without experience" (D. M. Hutcheson *et al.* 2001; page 944). Thus learning-effects modify behavior and in many lab experiments with humans, such learning effects may be substantial but has been difficult to capture.

It is clearly evident from this review that we have come a long way from the self-regarding and measurably wealth-maximizing *Homo economicus* models and are making strong advances in the understanding of economic exchange from a behavioral and physiological perspective. The reader most certainly has noticed how two games, the UG and the DG, originally used to measure the accuracy of game-theoretic predictions, have metamorphosed into a means to explain evolutionary forces, hormonal stress responses, sexually dimorphic emotions, and now the neural representations of emotional states!

Chapter Two

OT Enhances Generosity in the UG

Human beings routinely help others even when the helper receives no benefit and the person helped is a stranger. Altruistic behavior toward non-kin, exerting costly effort to benefit a stranger, is often found in laboratory economic experiments. Frequently the help offered to strangers in these games is sending an offer that is generously above a fair one. Why are people generous? Is there a benefit to acting generously toward strangers? Oxytocin may enhance prosocial emotions and reduces anxiety, allowing cooperation with strangers. Would enhanced prosocial emotions lead to enhanced other-regarding behaviors, like amplified generosity? If yes, generosity might be an evolutionary means to cooperation with non-kin. I hypothesized that subjects on OT would become more generous than those on placebo in the UG. The result shows that indeed, OT significantly enhances generosity.

Introduction

Among humans, cooperative behaviors like forming relationships with strangers and maintaining social bonds increase the likelihood of survival and provide opportunities for successful reproduction. The results of laboratory experiments using economic games show that cooperation is a primary and integral part of human economic exchanges. Humans often cooperate and act in a prosocial manner even at a detriment to their personal gain. It is widely accepted that human social bonds are characterized by acts of altruism (Stephanie L. Brown, R. Michael Brown 2005; Herbert Gintis *et al.* 2003; Herbert Gintis 2002). Altruism is the offering of a benefit to another at a cost to the altruist (Herbert A. Simon 1990; Robert L. Trivers 1971). What might motivate a person to act altruistically toward a stranger in an anonymous one-shot game? Individuals form and maintain social bonds using sympathy and empathy and provide benefits to others through helping and generosity (Stephanie D. Preston, Frans B. M. de Waal 2002b; Joseph Patrick Henrich *et al.* 2005; Adam Smith 1892).

Empathy provides the feeling or the imagination of how another person feels in response to a particular event and it helps in the understanding and predictions of others' thoughts and intentions; it is a robust process that underpins prosocial as well as antisocial behavior (Cameron Anderson, Dacher Keltner 2002; George Ainslie, Nick Haslam 2002). The emotional basis of altruism may lie in our possessing of prosocial emotions, including empathy, shame, and guilt (Herbert Gintis 2002). A study (with non-human apes) linked empathy to prosocial behaviors to help form attachment between conspecifics, which leads to generosity and altruism in apes (Stephanie D. Preston, Frans B. M. de Waal 2002b). Generosity is considered to be part of a variety of prosocial emotions, such as altruism, reciprocity, kindness, fairness, or doing something good (Michael Lewis 2002; Margery Lucas, Laura Wagner 2005; Catherine C. Eckel, Philip J. Grossman 1998; Gary E. Bolton *et al.* 1998; Frank Fincham, Julian Barling 1978).

Economics and game theory are based on the assumption that people can predict the actions of others'; backward induction, iterated elimination of dominated strategies, and the Nash Equilibrium (NE) require a system of beliefs about the decisions of others. These concepts are based on people understanding others' motives and beliefs (Tania Singer, Ernst Fehr 2005). The UG is a strategic economic game in which half of the players are endowed with some money (DM1) and the other half (DM2) is dependent upon an acceptable offer from DM1 for any money earned. DM2's rejection of an offer implies no gain for either of them while in acceptance both take home as much as they agreed to. Consider the situation of a DM1. She is endowed with $10 and is to offer some of that to an anonymous DM2 such that DM2 will accept. The sub-game perfect NE (SGPNE) is that DM1 keeps $9 and DM2 gets $1, and DM2 accepts that offer. Robust experimental results in the past twenty years show that DM1s are much more generous and typically offer $3 or more to DM2 and DM2s typically rejects offers if $2 or less (Werner Güth *et al.* 1982; Daniel Kahneman *et al.* 1986; Joseph Patrick Henrich *et al.* 2005; Colin F. Camerer, Richard H. Thaler 1995).

Why is $3 the accepted norm? Is generosity governed by expectations of fairness on the part of DM2 and DM1 knows that? Some suggest that fairness begets equitable payoff, while others suggest that fairness is a motivation in itself as it is the reciprocation for help or hurt (Gary E. Bolton, Axel Ockenfels 2005; Frans van Winden 2007a; Ernst Fehr, Urs Fischbacher 2002). Or is generosity governed by societal rules that are enforced by DM2s' punishments of unacceptably low offers? Some suggest that DM2's punishment of DM1 is altruistic punishment (Ernst Fehr, Simon Gachter 2002; Joseph Patrick Henrich *et al.* 2006), while others suggest that it is a self-regarding due to spite and anger (G. Gigerenzer, T. Gigerenzer 2005; Frans van Winden 2007b; Herbert Gintis 2002).

The neural mechanism of generosity is not well understood. Functional magnetic resonance imaging (fMRI) shows that when a person punishes another for lack of appropriate prosocial behavior the punishment itself is a reward in the altruist's dopamine pathway (D. J-F. DeQuervain *et al.* 2004). OT is present in the human brain and maybe associated with prosocial behaviors. It plays a central role in regulating positive social interactions, such as attachment and bonding and affects both social behavior and the mechanisms underlying social behavior (Karen L. Bales, C. Sue Carter 2002; R. Landgraf, I. D. Neumann 2004; D. Huber *et al.* 2005; Kerstin Uvnäs-Moberg 1998; Paul J. Zak, Ahlam Fakhar 2006; Paul J. Zak *et al.* 2005b; Paul J. Zak *et al.* 2004; C. Sue Carter 1998; Kristin M. Kramer *et al.* 2005; Alison B. Wismer Fries *et al.* 2005; James P. Curley, Eric B. Keverne 2005; Eric B. Keverne, James P. Curley 2004).

OT also affects social memory (Elena Choleris *et al.* 2003). In animals it can be released by sensory stimuli perceived as positive, including touch, warmth, and odors and also as the consequence of positive social interactions; it does so by inducing anti-stress-like effects such as reduction of blood pressure and cortisol, increases pain thresholds, and exerts anxiety reduction effects (Kerstin Uvnäs-Moberg 1998; Kerstin Uvnäs-Moberg, Maria Peterson 2005; R. J. Windle *et al.* 1997; Kerstin Uvnäs-Moberg, Eva Björkstrand 1998; T. Onaka 2004). OT has shown to reduce anxiety in humans by reducing amygdala activation, an area that has been implicated in the manifestation of fear (Peter Kirsch *et al.* 2005). OT receptors are concentrated in areas of the brain associated with emotions, such as the amygdala and the hypothalamus (Thomas R. Insel 1997; Kerstin Uvnäs-Moberg 1998; Kerstin Uvnäs-Moberg, Maria Peterson 2005; Kerstin Uvnäs-Moberg *et al.* 2005).

Humans with dysfunctional OT processing, like some autistic people, may be socially withdrawn (Brigit A. Völlm *et al.* 2006). OT has been shown to enhance trust toward strangers (Michael Kosfeld *et al.* 2005b), and trust stimuli have shown to increase OT levels in humans (Paul J. Zak *et al.* 2005b; Paul J. Zak *et al.* 2004). OT seems to permit humans to overcome their anxiety of dealing with strangers in social context (Kerstin Uvnäs-Moberg 1998; Kerstin Uvnäs-Moberg, Maria Peterson 2005; Kerstin Uvnäs-Moberg *et al.* 2005; M. Heinrichs *et al.* 2003). Research shows that OT crosses the blood-brain barrier after intranasal administration (Jan Born *et al.* 2002), providing a simple method for studying its effect on humans in a one-shot economic exchange with strangers in lab environment. For a comprehensive overview of clinical research findings on OT on humans and animals, see Bartz and Hollander, 2006 (Jennifer A. Bartz, Eric Hollander 2006) and Lim and Young, 2006 (Miranda M. Lim *et al.* 2005; Miranda M. Lim, Larry J. Young 2006).

OT is known to enhance attachment. It is natural to ask if attachment and generosity are associated in such a way that enhancing one would enhance the other. Would increased OT lead to enhanced generosity? In this paper I define an offer as generous if it provides more benefit than the average (Myrna Beth Shure 1968; Joseph Patrick Henrich *et al.* 2005;

Catherine C. Eckel, Philip J. Grossman 1996a). In particular, if an offer in the UG is above the average offer of the entire subject population, that offer is generous.

Empathy renders our emotions other-regarding, providing the motivational basis for other-regarding behavior (Tania Singer, Ernst Fehr 2005). Offering generous help is a component of empathy (Cameron Anderson, Dacher Keltner 2002; Michael Lewis 2002; Stephanie D. Preston, Frans B. M. de Waal 2002a). My hypothesis is that in the UG subjects will have increased generosity in the OT treatment compared with the placebo group.

As DM1's decision in the UG requires some form of social attachment and empathy toward DM2 in order to judge correctly what amount DM2 will accept, I propose that OT will affect the amount of money sent in the UG. By contrast, if the decision is purely strategic, OT will not make any difference. Similarly, since OT is hypothesized to only affect other-regarding preferences, I propose that the rejection amount (MinAccept) will not be influenced by OT. As control, I used a DG, which is a one-sided game where DM1s are endowed with a sum of money, $10, and are told that they may send any part of that to an anonymous stranger who has no say in the matter but must accept whatever handout is given. Thus this game has no strategy and no cooperation required. Any money offered by DM1 to a stranger is considered to be purely altruistic (Herbert Gintis 2000; Joseph Patrick Henrich *et al.* 2005). Because this altruism is not reciprocal, i.e. the DG is not cooperative and appears to be dissociated from response, I hypothesize that OT will not make a difference in the amount of money sent by DM1 in the DG.

Materials and Methods

This experiment was approved by the Institutional Review Boards of UCLA and Claremont Graduate University. There was no deception in any part of this experiment. We recruited only male subjects because of the possible unintended miscarriage in females—oxytocin is used to induce labor. 83 male students responded to an email advertisement-invitation to participate in an experiment and to earn some money. The subjects arrived to UCLA California Social Science Experimental Laboratory (CASSEL) either in the morning at 9:30 am or in the afternoon for the second session at 1 pm and were given a short medical screening for possible dangerous interactions with oxytocin. All subjects were admitted and seated in a cubicle with two computers. Each subject was either provided 40 IU of oxytocin (Jan Born *et al.* 2002; Osama Salha, James J. Walker 1999; Mary B. Munn *et al.* 2001) or normal saline by nasal inhaler. This was a double-blind study and neither the subjects nor the investigators had the information about which substance the subject received. Because oxytocin had to be kept refrigerated, the saline was too so the investigator was blind to which substance was administered based on temperature. The length of time spent with each subject for the administration of oxytocin or saline was about one minute. The drug administration went without any problems, no subject required medical treatment, no adverse side effects, and no after-treatment help was requested.

The time required for oxytocin to reach behaviorally relevant increased levels is approximately 45 to 60 minutes (Jan Born *et al.* 2002). In this period, the subjects were asked to fill out two surveys on the computer, each taking approximately 15-20 minutes. The surveys were used to test for consistency in answers and to collect demographic information known to influence decision-making (Michael Kosfeld *et al.* 2005b; Paul J. Zak *et al.* 2004). The subjects were told that they could surf the Net, respond to email but they were asked to not make any phone calls or talk to anyone in the laboratory. 60 minutes after oxytocin application, each subject played a one-shot ultimatum game and dictator game. Because of computer problems, the first group in the experiment—13 subjects—was not able to play the games and their data was removed. One subject did not follow instructions and was dismissed after $5 payment was given to him as show-up fee. One additional subject was removed in the process of the data analysis as his data appeared to be outlier compared with research results of others in the US (Colin Camerer

2003). 68 subjects remained in the analysis of this experiment. The mean age of the participating students was 21.75.

The computer version of the one-shot ultimatum and dictator games takes a couple of minutes to play. Upon completion of all of these tasks, each subject individually left the computer lab to collect his winnings in privacy in cash, $30 on average, from the lab administrator. Upon leaving with the payout, each subject was also handed a precautionary leaflet that provided information about the possible side effects of oxytocin and offered phone numbers and contact names in case of an emergency for the following 24 hours.

Each subject received self-paced instructions and a quiz to make sure they understood the games; not passing the quiz means elimination from the experiment. In this experiment, each subject played both as DM1 and as DM2 sequentially and without any knowledge of what choices their partners made. The computer program asked how much money they wanted to send to their computer-matched partner in the ultimatum game, what their rejection level (MinAccept) was for the ultimatum game, and how much money they wanted to send in the dictator game.

Results

I found support for all three hypotheses. Similarly to experimental results of UG and DG by others, I found that our variables were not normally distributed. Although nonparametric statistics was the primary analysis method, parametric statistics was used to confirm the results. If the findings are robust in nonparametric statistics, parametric tests should provide the same results. The amount of money sent in the UG was significantly higher in the OT treatment ($4.86) than in the placebo treatment group ($4.03) (Mann-Whitney U test (M-W-U) two-tailed p = 0.005) but there was no difference between the amount offered in the DG ($3.77 OT and $3.58 placebo) (M-W-U two-tailed p = 0.506) and in the rejection amount of MinAccept ($3.03 OT and $2.91 placebo) (M-W-U two-tailed p = 0.782).

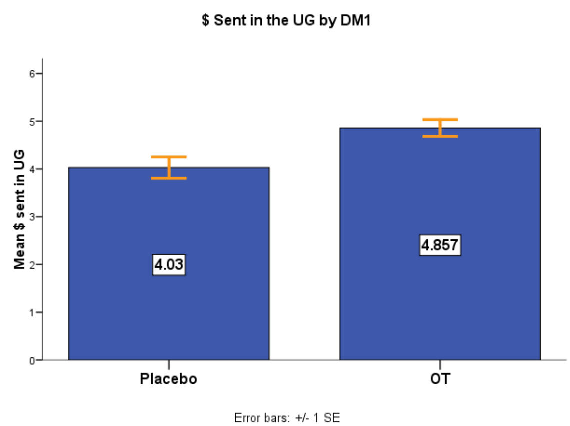

Figure 2.1 Average amount of money sent in the UG with standard error bars.

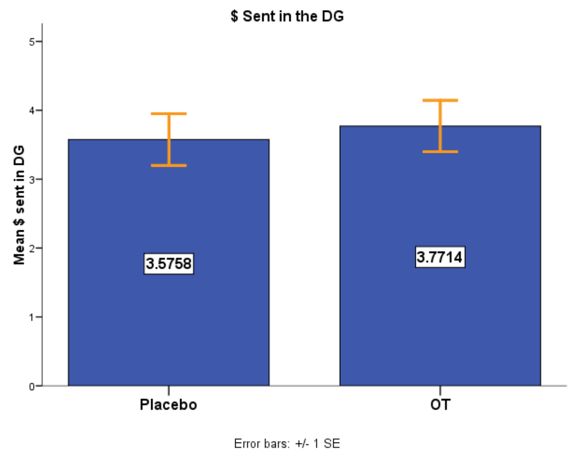

Figure 2.2 Average amount of money sent in the DG with standard error bars. The placebo group is show on the left and the OT treatment group on the right.

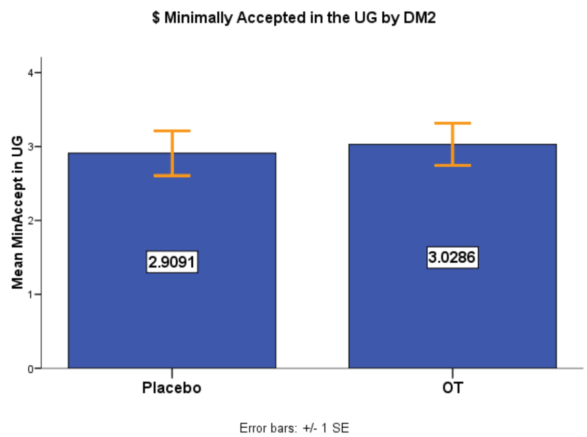

Figure 2.3 Average amount of money stated as MinAccept in the UG with standard error bars.

In general, only 3% (2 subjects, both in the placebo group) offered the SGPNE of $1 in the UG and 18% (12 subjects) offered the NE of $0 in the DG with a near equal mix between treatment groups. 4% (3 subjects, 2 from the OT group) accepted $0, which is smaller the SGPNE of $1; 27% (18 subjects, 8 from OT group) accepted $1. Overall 40% of the subjects would accept less than 30% of the pot. Most previous lab experiments show that most DM2s typically reject an offer that is less than 30%—for a thorough review see (Colin Camerer 2003; pages 50-58), hence the population sample drawn from the University of California, Los Angeles, student body is systemically accepting lower offers than the average.

The expected likelihood that an offer will be accepted was nearly identical in the two treatment groups and was 73%. The range of MinAccept was between $0 and $6; the average, including both treatment groups, was $2.97. I looked at the average amount of money sent by subjects in the OT and the placebo treatments and subtracted from this the average accepted amount to see which group sent a more generous amount than the MinAccept required.

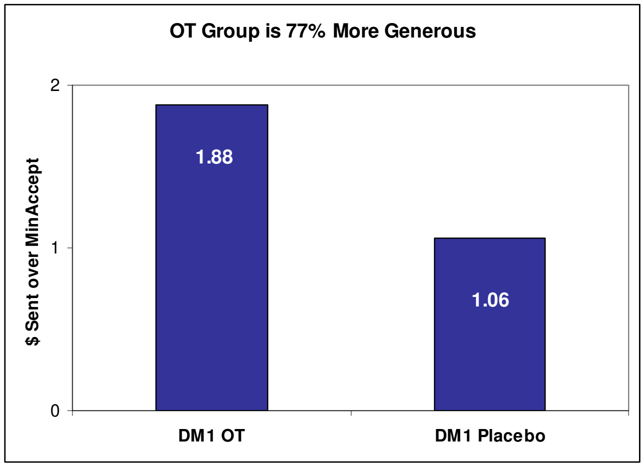

Figure 2.4 DM1s in the OT treatment were 77% more generous than DM1s in the placebo

The OT group was 77% more generous. They offered an average of $1.88 range [-1, +5] while the placebo $1.06 range [-2, +4] over the MinAccept; the difference between the two groups is highly significant (Mann-Whitney U-test $p = 0.005$). Therefore, subjects in the OT group took less money home in the UG than the placebo. Once rejections of offers are included, the mean take-home for subjects in the OT group was $5.06 and for the placebo $5.70 and the difference is significant (Mann-Whitney U-test $p = 0.009$).

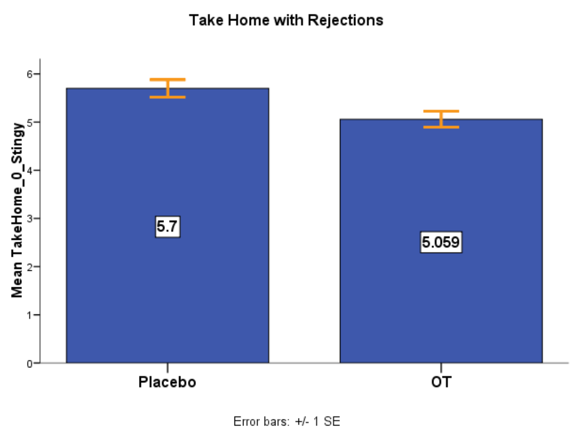

Figure 2.5 Average amount of money taken home in the UG.

Thus subjects in the OT group took home less as a result of their generosity.

Discussion

> When to the interest of this other person, therefore, they sacrifice their own, they accommodate themselves to the sentiments of the spectator, and by an effort of magnanimity act according to those views of things which, they feel, must naturally occur to any third person.
>
> Adam Smith "The Theory of Moral Sentiments" (1790).

I have shown that OT increased generosity in the UG. Although the central tendency analysis of the amount of money sent in the DG did not show any significant differences between the treatment groups, I noticed other significant differences between the OT and placebo treatment groups in the DG. OT affected the DG decision differently from how it affected the UG.

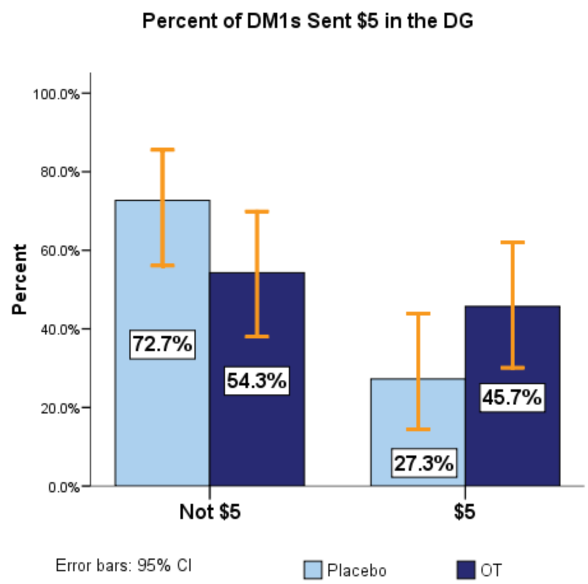

Figure 2.6 Percent of subjects sending $5 in the DG by treatment group.

While in the UG the amount of money sent increased (shifted to the right of the mean of the amount of money sent) and made DM1s more generous, in the DG the number of subjects sending certain amount increased (shifted to the right of the mean of number of subjects) particularly in the $5 group—see figure 2.6.

The difference between the two treatment groups is not captured by statistical tests, even though the percentage variation in the $5 groups is large. The percent of subjects who sent $5 is 67% larger than the percent in the placebo group. Thus with respect to the number of subjects offering a larger amount, or more specifically the most frequently sent amount of $5, OT affected both DG and UG, although in the DG the amount of money offered per se is not increased. This finding, though statistically insignificant, should not be dismissed as noise without further study in another experiment. The counter-intuition behind having OT influence the DG is that OT is known to influence attachment and bonding, which suggests that exchanges where reciprocity is not considered should not be influenced. Finding that OT influences some people to offer a fair split indicates that either OT influences prosocial considerations that are void of reciprocal expectation, or that prosocial elements in the UG and the DG are not easily separated by subjects when their OT-level is increased. Perhaps, as a key function of OT is to remove the fear of strangers and allow cooperation between non-kin, OT enhances cooperation when otherwise it is not necessary.

We can see in figure 2.7 below that the percent of subjects sending larger sums of money in the DG is more in the OT treatment group than in the placebo and that the trend of more subjects offering less is magnified in the placebo group. 54% more subjects joined the “send less” effort in the placebo group.

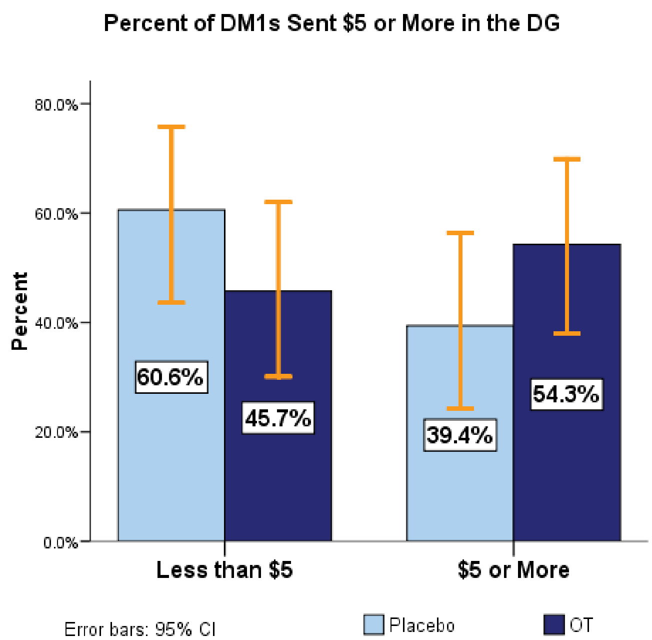

Figure 2.7 The distribution of the percent of subjects who sent $5 or more or less than $5 in the DG in the two treatment groups.

It is interesting to find that OT had no affect on MinAccept. On the one hand, this signals that subjects are not cognitively impaired by the affect of OT because there is no difference in rejection rates between OT and placebo. On the other hand, this finding provides some answers to the debate of the two schools of thoughts about what drives the rejection of positive money amounts in the UG. One school suggests that it is an altruistic norm-enforcement (other-regarding) by which a DM2 enforces what is considered to be fair to receive; thus one would expect that OT influences this decision. The other school of thought is that rejection of positive money amounts by DM2 is self-regarding driven by anger and spite. If MinAccept was set based on a personal preference of what is fair to the particular DM2, we would not have expected OT to influence that decision, as the MinAccept decision then is not other-regarding.

As OT did not affect the rejection amount of DM2s in any direction, there might be some culturally accepted amount that subjects feel if fair. However, this finding did not conclusively decide if the chosen MinAccept was set based on a personal preference or a culturally set norm, only suggests that OT did not influence that decision. We thus leave the decisive resolution of this debate for a future study aimed specifically at finding whether rejection is other-regarding or self-regarding.

Our subject filled out surveys with a variety of demographic questions as well as questions referring to how trusting they felt toward strangers, how attached they felt to their past and current romantic partners, if they trusted their romantic partners enough to share their feelings, and how they resolved their anger. The answers to any of the survey questions should not have been influenced by OT since the surveys were filled in earlier than optimal upload. Nonetheless, some effects were visible in subject behavior about 10 minutes after OT administration. For example, there was a yawn-and-stretch that moved through the subjects in waves the appropriate order in which they received treatment. As we were blind whether subjects received OT or placebo, the yawns and stretches could well have been coincidental, except that they happened in every experiment at about the same time. This suggests that OT might have some effect shortly after administration, albeit not full effect, and some of the survey questions might show a pattern of OT influence.

Several questions on the survey asked about trust toward strangers. Three of these questions followed one another and consistent response required either and a-b-a (trusting strangers) or b-a-b response (not trusting strangers); response in any other combination indicated inconsistency. The three trust-questions were as follows: (1) Most of the time, people (a) try to be helpful; (b) are mostly just looking out for themselves; (2) Most people would try to (a) take advantage of you if they got a chance; (b) be fair; (3) Generally speaking (a) most people can be trusted; (b) you can't be too careful in dealing with people.

In general, 39 subjects were consistent and 26 inconsistent in their answers for these three survey questions. It is important to note that inconsistency in these questions did not affect the subjects' decision analysis results in the games (Mann-Whitney U-test on dummies set to test the significance of consistence and inconsistence in the amount of money DM1 sent in the UG game p = 0.94, in the DG: p = 0.703, and MinAccept: p = 0.106, all 2-tailed). Of those subjects who chose consistently, 24 were in the OT and 15 in the placebo group, suggesting that OT did not sedate our subjects—see figure 2.8 for details.

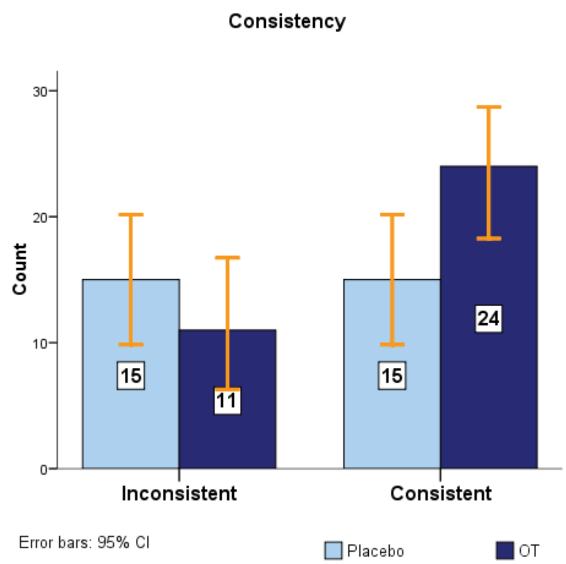

Figure 2.8 The influence of OT on subject consistency. Subjects are more consistent (right side of image) in the OT (dark bars) treatment group than in the placebo.

The difference between the two treatment groups with respect to consistency is not significant (Mann-Whitney U-test p = 0.131), thus OT did not influence subject consistency.

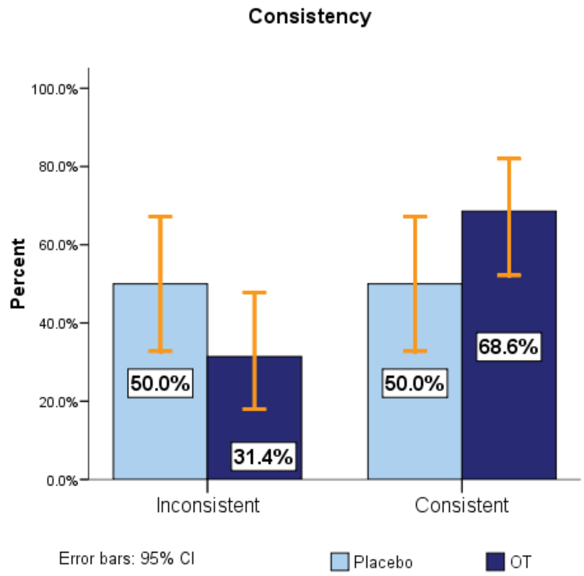

Figure 2.9 Consistency in percentages.

Of the consistent answers 15 subjects answered “trusting” and 25 “distrusting”. 13 out of the 15 trusting subjects were in the OT group and only 2 in the placebo treatment group; the difference between treatment groups is significant (Mann-Whitney U-test Exact p = 0.027 2-tailed)-see figure 2.10 below.

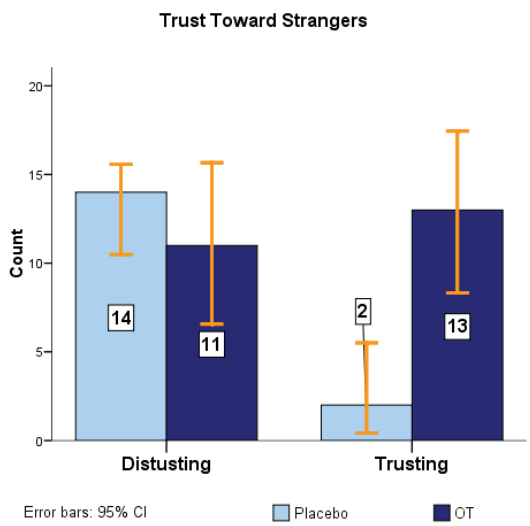

Figure 2.10 Significantly more subjects felt trust toward strangers in the OT (dark) treatment group (right 2 bars) than in the placebo (light). In the placebo treatment group more subjects felt distrust (left 2 bars) toward strangers.

OT appears to have significantly affected how subjects felt toward strangers, with an increase in trust toward strangers. Survey questions about kin-relation (romantic partner attachment) were scaled on the 1-7 Likert scale. Questions about attachment sometimes were about trust toward romantic partners (past and present partners) and other times more about how anxious the person felt about commitment to be attached or fear of the partner’s commitment to be attached. As OT is a neurobiological marker for attachment, one might expect that OT would enhance the feeling of attachment and trust toward strangers but what about toward kin? OT did not affect the feelings of attachment and trust toward kin (Mann-Whitney U-test p = 0.798) but it moderately affected trust toward strangers (Mann-Whitney U-test p = 0.066 2-tailed).

Furthermore, I found by correlations that trust toward strangers is significantly associated with OT (41% Pearson, sig. 0.0005), while kin's association with OT is next to nothing (Pearson 3% sig. 0.80).

To see if other factors participated in the enhanced generosity, we analyzed the demographics variables for their influence on generosity given the OT treatment. We found no significance of any other variables. For example, age did not affect the generosity of subjects (Mann-Whitney U-test $p = 0.929$) or stinginess (Mann-Whitney U-test $p = 0.338$). We also know that OT neither makes subjects more risk-takers nor more risk-averse (Michael Kosfeld *et al.* 2005b). Thus the only factor (of those factors we measured) affecting subject generosity appears to be oxytocin itself.

This finding suggests that as OT is important in our dealing with strangers. It further suggests that as trust and attachment within kin is well established, there might similar mechanisms that permit us to trust and be generous toward strangers. Oxytocin appears to be an evolutionary hormone that makes subjects more trusting and generous in order to enhance cooperative and positive social interactions with strangers. Generosity can initiate gift-giving and therefore a virtuous circle of reciprocity. Generosity is a primary long-term mating strategy (David M. Buss 1995). As I showed that generosity can be enhanced by varying the level of OT, and that OT naturally varies in level throughout our daily lives, it is expected that generosity is enhanced naturally by our changing levels of OT when the appropriate stimuli is provided by our external environments.

Chapter Three

Vasopressin and Punishment

Introduction

In a variety of economic experiments it has been shown that humans make their decisions not based purely on monetary incentives. Experiments show that subjects send more money in one-shot blinded games than expected by game theoretic models but no explanations have so far been forthcoming for "why" people make their decisions this way. Some theories place these behaviors into a variety of categories, such as self-regarding or other-regarding notions, pro-social behaviors or altruism (G. Gigerenzer, T. Gigerenzer 2005; Frans van Winden 2007a; Herbert Gintis 2002; Ernst Fehr, Simon Gachter 2002; Joseph Patrick Henrich 2006), but none explains why a person would choose to be pro-social, altruistic, or other-regarding with a stranger in one-shot blinded games. In games that continue with the same players for some time or in games where the participants learn about one-another by direct contact or by reputation, reciprocity may build up relations where offering more in economic laboratory experiments is expected. But in games where subjects are blinded from one-another and only a single game is played, reciprocity and reputation cannot explain other-regarding and altruistic behaviors.

In this paper, I show that by enhancing the influence of certain emotions by the use of ancient evolutionary hormones, it is possible to initiate particular behaviors in humans, thereby providing answers to the "why" for pro-social and other-regarding behaviors in these one-shot blinded games. Based on animal and a few human studies, we know that arginine vasopressin (AVP), an evolutionary hormone, plays a significant role in some behaviors associated with kin protection; AVP has shown to influence the behavior of small mammals by making them more reactively aggressive (J. M. Koolhaas *et al.* 1990; Craig F. Ferris *et al.* 2006); AVP is necessary for social memory (Jennifer N. Ferguson *et al.* 2002), and has also shown to be involved in human depression and aggression (G. Scantamburlo *et al.* 2005; Zul Merali *et al.* 2006; Sergueï O. Fetissov *et al.* 2006). Can the administration of AVP influence subjects to punish those who violate a social norm in one-shot blinded economic games?

Animal studies are more frequent than human AVP studies, though not as extensive as studies of oxytocin (OT) are in mammals. In a study by Ruscio et al., 2007, the prairie vole (Microtus ochrogaster) was studied growing up in a variety of housing conditions, such as healthy and caring with siblings or conspecifics versus in isolation (Michael G. Ruscio *et al.* 2007). They show that central AVP activity (natural release, not artificial administration) increases under stressful (isolated living) conditions of otherwise socially active prairie voles who otherwise stayed in social kin-group formation. In fact, they show changes in brain physiology (denser AVP receptor regions) in those voles that were kept in isolation relative to those that were housed under more social conditions. This implies that higher stress increases the ability of AVP reception by increasing their density.

Lim and Young show how AVP and OT work together regulating affiliative behavior and social bonding in animals. They list three factors that are necessary conditions for social attachment: 1) approach: the organism must be willing to approach and engage a conspecific who is non-kin (must remove fear of strangers); 2) identity: the organism must be able to identify individuals based on social cues and form memories (must tell strangers from kin and strangers who were met before from new strangers); 3) bonding: given the appropriate conditions, bond can form with the new individual (allow attachment with strangers) (Miranda M. Lim, Larry J. Young 2006). It has been shown in a variety of animal studies that both AVP and OT are together responsible for bond formation and attachment (C. Sue Carter 2003).

In the vole, AVP is selective. In the monogamous prairie vole AVP increases the amount of social interaction but in the promiscuous montane vole it does not (Larry J. Young *et al.* 2006). In animal studies, central (released by or administered into the brain) or peripheral (released or administered into the blood stream) AVP concentrations do not have positive correlations and it is unknown if central and peripheral concentration levels in humans correlate (C. Sue Carter 2007;R. Landgraf, I. D. Neumann 2004). Activation of AVP is time and hormone dependent, meaning that response to the exposure of AVP differs depending on the time and the duration of the release and the presence of other hormones, such as OT, which may act (sometimes) as antagonist to AVP (D. Huber *et al.* 2005).

AVP has three known receptors: V1a, V1b, and V2. V1a is connected to the vascular system (A. Pena *et al.* 2007) and understood to play a central role in social bonding (J. T. Winslow *et al.* 2005) and facilitating positive social behavior (M. M. Cho *et al.* 1999). V1b is important mediator of the hypothalamic-pituitary-adrenal axis response to chronic stress (SJ Lolait *et al.* 2007), and V2 is known to be important in the maintenance of water homeostasis through interaction with V2r (V2 receptors) in the kidneys (MB Petersen 2006). A recent study shows that nasal application of 20 IU AVP affected social communication processes (differently in men and women), indicating that the targeted V1a receptor was activated (R. R. Thompson *et al.* 2006). Additionally, animal studies show that V1a antagonist in mice and rats reduced anxiety-related behavior and impaired social interaction (Nobuaki Egashira *et al.* 2007; C. A. Pedersen, M. L. Boccia 2006). However, V1a receptors were also affected when OT was administered to postnatal (1-day old) prairie vole pups (K. L. Bales *et al.* 2007), indicating that AVP might not be the only hormone playing a role at activating V1aR by AVP.

Increases in AVP are associated with amplification of corticotrophin releasing factor (CRF) (C. R. DeBold *et al.* 1984), particularly in situations of stress, which appears to increase some forms of aggressive behaviors that are associated with defense (C. Sue Carter 2007). Coccaro et al., found that increased cerebrospinal fluid AVP was correlated with a history of aggressive behavior in humans (E. F. Coccaro *et al.* 1998). Serotonin also plays an important role in regulating AVP (and OT), possibly down regulating AVP (up regulating OT) (Michael G. Ruscio *et al.* 2007). Animal studies showed that both OT and AVP are involved in social memory, but whereas OT appears to allow the formation of attachment, AVP appears to protect social memory from being lost (Isadora F. Bielsky, Larry J. Young 2004; Jennifer N. Ferguson *et al.* 2002; Jennifer N. Ferguson *et al.* 2000; Richard A. Depue, Jeannine V. Morrone-Strupinsky 2005).

This study opens the door to test the hypothesis if AVP influences decision-making, in measurable ways, with subjects playing the ultimatum game (UG), trust game (TG), and the dictator game (DG). In all three games in this experiment, two anonymous subjects play one-shot games four times, with randomly matched partners each time. They play with their show-up fee, which they are dividing between themselves in some manner. The purpose and the strategy of the three games are different. In the DG, decision-maker1 (DM1) receives $10 and is told that he may send any part of that to an anonymous person in the room (DM2). DM1 may decide to send no money at all and DM2 must accept that decision. There is no further exchange, the game is over. The Nash Equilibrium (NE) suggests that DM1 earns $10 and DM2 $0, but in laboratory experiments the average amount sent is between $1.50 and $5 dependent upon how (blind, double-blind, known identity) and where (what country) the game is played, with the mean offers of 20% of the stash, and around 20% of the subjects send the NE of $0 (various studies are summarized by (Colin Camerer 2003; pages 57-58).

The UG incorporates an additional step: DM2 may reject DM1's offer, in which case neither DM1 nor DM2 earns any money. Thus, the strategy here for DM1 is to allocate "just enough" money to DM2 to have the offer accepted, in which case they both earn the amount agreed to. The Sub-Game Perfect NE (SGPNE) in the UG is $9 to DM1 and $1 to DM2 but in laboratory experiments this is rarely achieved. Offers range between $3 or $4 and offers smaller than $3 are rejected by half of the participants; about 75% of the subjects send an even split (Werner

Güth *et al.* 1982; Daniel Kahneman *et al.* 1986; Joseph Patrick Henrich *et al.* 2005; Colin F. Camerer, Richard H. Thaler 1995; Colin Camerer 2003; pages 50-55).

The TG is the only game in this experiment in which DM2 receives feedback of DM1s actual decision. In this game, just as in the others, DM1 is told that he may send any part of his $10 show-up fee to an anonymous stranger, DM2. Any money he sends to DM2 triples en route, from which DM2 may choose to return any part to DM1. However, in this game DM2 is not obligated in any way to send any part of the tripled sum back. The SGPNE suggests that in such risky environment, in the case of one-shot games, DM1 will keep his entire endowment and send $0 to DM2. DM2 will also keep his endowment and both players walk away with $10. If DM1 trusts DM2, he would send his $10, which triples. DM2 then receives $30 plus his own show-up fee. If DM2 is trustworthy, both subjects would end up with $20. There is a mutual benefit to cooperation, but DM2 may take the entire $40 leaving $0 for DM1 without any punishment. In lab experiments, typically 40% of the money is sent to DM2s who send back about a third of the tripled amount (Colin Camerer 2003).

Administered AVP has been shown, in animal studies, to cause reactive aggression in protecting kin; thus it is shown to be connected to attachment but in a different way from OT. OT was found, in two studies, to influence decision-making by humans becoming more trusting in the TG (Michael Kosfeld *et al.* 2005b) and by becoming more generous in the UG (Angela A Stanton 2007). The purpose of the two hormones appears to be the enhancement of social interaction in some way. As kin-type altruistic behavior is understood to be selfish (Robert L. Trivers 1971), the question remains whether AVP, which in animal studies appears to activate for the protection of kin only, would function similarly in humans, e.g. make humans more selfish. If the function of AVP in humans is also that of kin-protection, perhaps this will manifest itself in the protection of resources available for kin, making subjects stingy, less trusting, and more punishing if the expected resources are not forthcoming with the offers DM1s make in these games.

Thus I hypothesize that both DM1s and DM2s will be affected by AVP. DM1s on AVP will send less money in the UG and in the TG to their anonymous partner (non-kin) than subjects in the placebo treatment group because if AVP enhances kin-protection, resource-savings for self and kin should over-ride the helping of strangers. Previous results with OT in the UG showed (Chapter2 Angela A Stanton 2007) that the rejection decision (MinAccept) of the subjects was not influenced by OT. This suggests that this decision might not be prosocial but perhaps is selfish. If so, AVP might influence this decision as well, making subjects punish more by increasing their MinAccept. I hypothesize that MinAccept will be higher for those in the AVP treatment group than those on placebo. Furthermore, when playing as DM2 in the TG, subjects on AVP will punish small offers more than the placebo group; I hypothesize that the amount of money returned to DM1 from the tripled amount DM2 received will be smaller in the AVP treatment group than in the placebo. And finally, as the decision in the DG has been shown to not be prosocial (not affected by OT) but is not selfish either, I hypothesize that in the DG AVP will not make any difference with respect to how much money DM1 sends.

Materials and Methods

This experiment was approved by the Institutional Review Boards of UCLA and Claremont Graduate University. There was no deception in any part of this experiment. We recruited only male subjects because female status in the menstrual cycle, potentially, places an additional influence that we are not able to control for without taking blood (Paul J. Zak *et al.* 2005a). 64 male students responded to an email advertisement-invitation to participate in the experiment and to earn some money. The subjects arrived to UCLA California Social Science Experimental Laboratory (CASSEL) either in the morning at 10:30 am or in the afternoon for the second session at 1:30 pm and were given a short medical screening for possible drug interactions with vasopressin. Two were released because they did not meet the medical criteria for AVP administration. One subject registered the second time for the same experiment and another subject could not stay all the way through the experiment and so both were paid the show-up fee and released. Two additional subjects' results were removed from the database after finding that they had serious difficulty passing the quiz in the UG, which is designed specifically to ensure that subjects understand the game. The mean age of the remaining 58 participating students was 21.77.

All subjects were admitted and seated in a cubicle with two computers. Each subject was either provided 20 IU of AVP (Jan Born *et al.* 2002) or equivalent normal saline by nasal inhaler. The first day's experiment provided for a confused environment because the AVP sprayers were not functioning properly. In the analysis it became evident that the subjects in both treatment groups were affected by the confusion and the data is significantly different from data collected on the other days. As a result, the first day's data was removed from analysis (11 subjects). Of the remaining 47 subjects, 27 were on AVP and 20 on placebo. This was a double-blind study and neither the subjects nor the investigators had the information about which substance the subject received. Because AVP had to be kept refrigerated, so was the saline to keep the investigator blind to which substance was administered based on temperature. The length of time spent with each subject for the administration of AVP or saline was about one minute. Blood pressure was measured immediately after the administration of AVP and at the end of the experiment to make sure that there was no adverse rise in blood pressure as a result of AVP. The AVP administration went without any problems, no subject required medical treatment during or after the experiment, no adverse side effects, and no after-treatment help was requested.

The time required for AVP to reach behaviorally relevant increased levels is approximately 45 minutes (Jan Born *et al.* 2002). In this period, the subjects were asked to fill out two surveys on the computer, each taking approximately 15-20 minutes. The surveys were used to measure personality traits and to collect demographic information (Paul J. Zak *et al.* 2004). After completing the surveys, the subjects were told that they could surf the Net and respond to email but they were asked to not make any phone calls, send or receive text messages, or talk to anyone in the laboratory. 45 minutes after AVP application, each subject played one-shot TG, UG, and DG four times with random match of different partners each game.

The computer version of the UG, DG, and TG take a couple of minutes each to play. Upon completion of all of these tasks, two games were selected for pay-out by a volunteer who pulled two ping-pong balls from an urn and each subject individually left the computer lab to collect his winnings in privacy in cash, $30 on average, from the lab administrator. The length of the experiment was approximately 2 hours ($\pm$ 15 minutes dependent upon the subject-pool size because of the length of the medical evaluation). Upon leaving, each subject was handed a paper that provided information about the possible side effects of AVP and offered phone numbers and contact names in case of an emergency for the following 24 hours.

In this experiment subjects were randomly assigned to play anonymously with one another one-shot games on the computer with randomization that was meant to eliminate the effects of repeat play. Note, however, that on some days the subject size was too small to ensure full randomization. The effects of this on the decision-making are analyzed and described in the results section. In this experiment, each subject played both as decision-maker1—proposers in the UG—(DM1) and as decision-maker2—responders in the UG—(DM2) at once and without any knowledge of what choices their partners made. Each subject also played the trust game (TG), in which DM2s received feedback on how much money they were sent by the DM1. In the TG, because each subject plays both roles, both players learn about the DM1 decision of the other, though otherwise the subjects remain anonymous to each other. Nonetheless, this allows for some evaluation of the type of subject pool present in the computer lab.

The games were computerized; the computer program asked how much money they wanted to send to their anonymous computer-matched partner (in the UG), how much money they would accept (MinAccept) from their anonymous partner (in the UG), how much money they would to send to an anonymous person (in the DG), how much money they wanted to send knowing that any amount sent would triple in value and that DM2s may send some or none of the money back to them (TG) and how much money they wanted to send back from the tripled value of the money they received from their anonymous partner (TG). Stata 9 and SPSS 15 were used for the statistical analysis. Similarly to experimental results of others (Kevin J. Haley, Daniel M. T. Fessler 2005) and also in chapter 2 of this dissertation, variables in the DG were found to be not normally distributed based on heteroskedasticity of the residual. As a result, nonparametric statistics was used for the rest of the analysis.

Results

Tentative results show that the hypotheses were correct, with one caveat: AVP had significant affect on subjects in small groups (on days when only few volunteers showed up and five or fewer subjects played the games) but not in large groups (groups that had six or more subjects). In particular, subject on AVP set their MinAccept at significantly more punishing levels in the AVP treatment than the placebo treatment in small groups. I found that in the TG subjects on AVP punished more those who sent less than the average but when more than average was sent, AVP subjects in small groups were more reciprocating. It is important to note that these results are tentative, and this is discussed in greater detail below. I review the results of the games, starting with the UG.

The Ultimatum Game

For each type of game the subjects played four games. In order to gain more robust statistics, I wanted to append the four game results to create a dataset with 188 observations, but I needed to ensure that the four games within the type of game (like four UGs) all came from the same distributions. I checked for learning effects by creating dummies for each game and found that I was able to aggregate in some games but not in others. In the UG I did not find any learning effects (Kruskal-Wallis test p = 0.873), as can be clearly seen in figure 3.1.

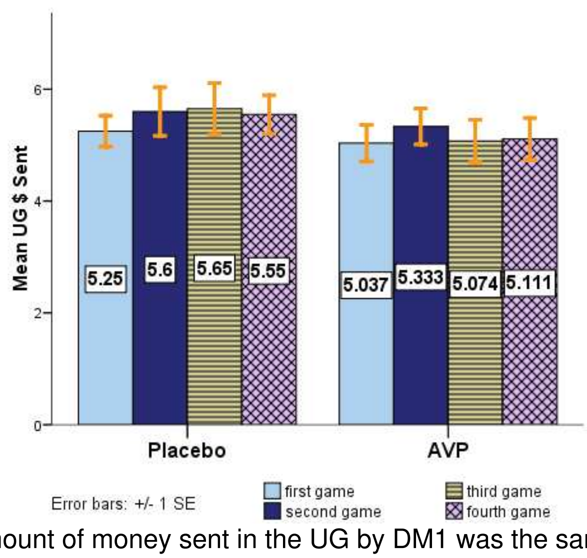

Figure 3.1 The amount of money sent in the UG by DM1 was the same in the 4 games

On two days only small pools of subjects volunteered (five or fewer) while on the other days, large pools of volunteers showed up. As I aggregated the data for the four games, I showed significant differences between the large and the small groups (Mann-Whitney U-test p = 0.019). I split the dataset of the UG and created "Small Groups" (SG) (32 observations) and "Large Groups" (LG) (156 observations). The amount of money sent in the UG was different between treatment groups (Mann-Whitney U-test UG: p = 0.004) in SG but not different in LG Mann-Whitney U-test p = 0.523). This shows that AVP might have made subjects in SG stingier but not in LG. In light of the literature with animals, suggesting reactive aggressive behavior in protecting kin, stinginess might imply that saving resources is a function of kin-protection. However, as the total number of subjects in SGs was very small (eight subjects total), the results could be noise.

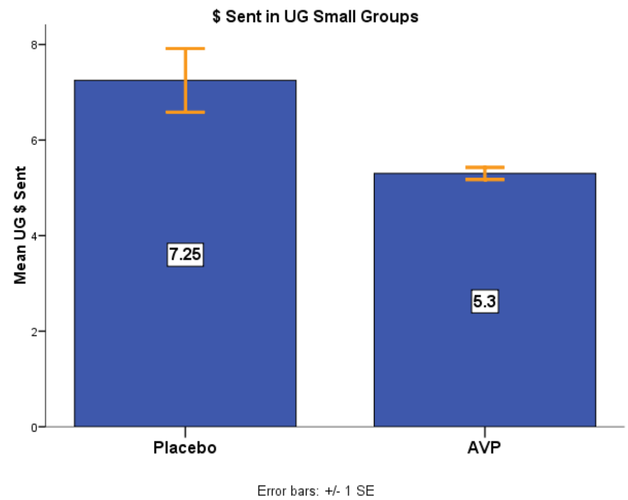

Figure 3.2 The amount of money sent in “Small-Groups” in the UG

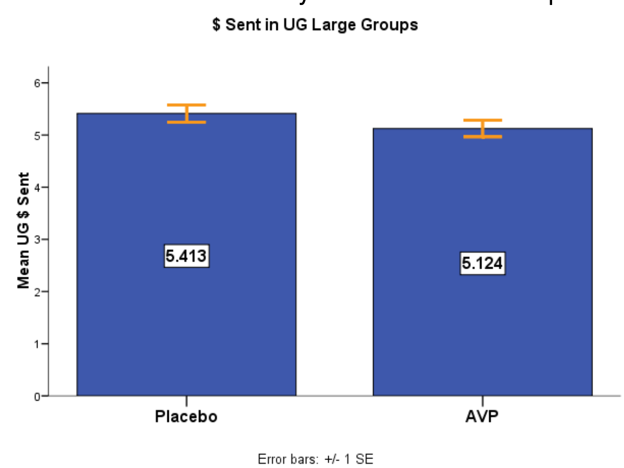

Figure 3.3 The amount of money sent in “Large Groups” in the UG

In order to check if the result found in small groups is more likely to be noise than true differences between the small and large groups, I ran the Chow-test using SG and LG as the two subgroups. The Chow test results show definite differences between the two groups (F = 68.25; p = 0.000) but the residual of the regression is heteroskedastic. I reduced the heteroskedasticity by rerunning the regression with weighted least squares. The Chow-test results remained unchanged (F = 104.08, p = 0.000) indicating that there is a strong likelihood that there are true differences between small and large groups with respect to decision-making in the UG when on AVP versus placebo. Note in figures 3.2 and 3.3 how the placebo treatment group’s decision changed (from $7.25 in SG to $5.41 in LG) to incorporate group-size dynamics but not the AVP treatment group (from $5.30 in SG to $5.124 in LG). The difference between the SG and LG placebo groups is highly significant (Mann-Whitney U-test p = 0.002). This suggests that the AVP treatment group might have been inhibited from changing to adapt to groups-size dynamics, which can also be related to reactive aggression, which is not as likely to manifest itself in large groups.

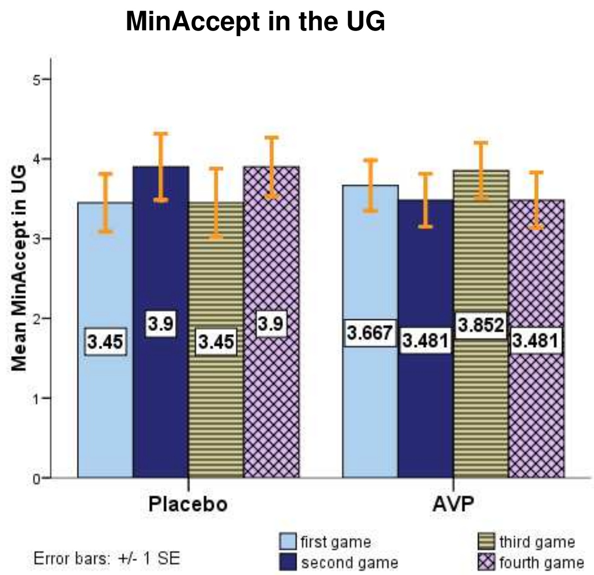

Figure 3.4 MinAccept in the four games

The rejection amounts of the UG was also not influenced by learning effects (Kruskal-Wallis test p = 0.931), I aggregated the data and compared whether differences existed between SG and LG. I found significant differences between SG and LG with respect to the placebo treatment groups but not AVP (Mann-Whitney U-test p = 0.002 for placebo and p = 0.770 for AVP).

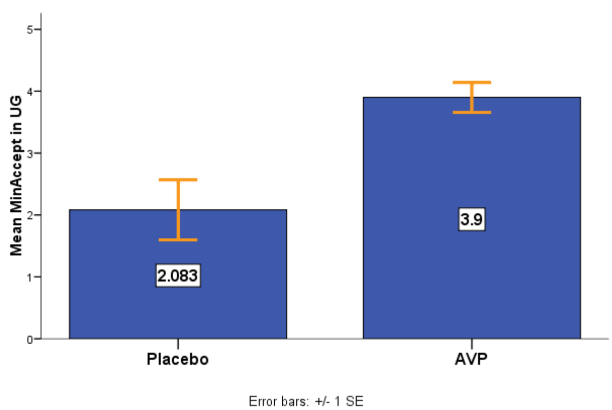

Figure 3.3 MinAccept in Small Groups.

The MinAccept decision of the UG was significantly affected in that in SG subjects on AVP considered significantly larger amount to be acceptable, in fact 88% larger! In SG, where the probability of playing with the same subject again increases (the four games were played with random matching of anonymous partners), those on placebo adjusted their MinAccept to be more forgiving; they accepted as little as $2.08 from their anonymous partner, an amount that is well below the typical average of $3 seen in laboratory experiments (Colin Camerer 2003). In SG those on AVP demanded to receive $3.90 or they punished. The difference between the two treatments group-responses in SG is highly significant (Mann-Whitney U-test p = 0.004).

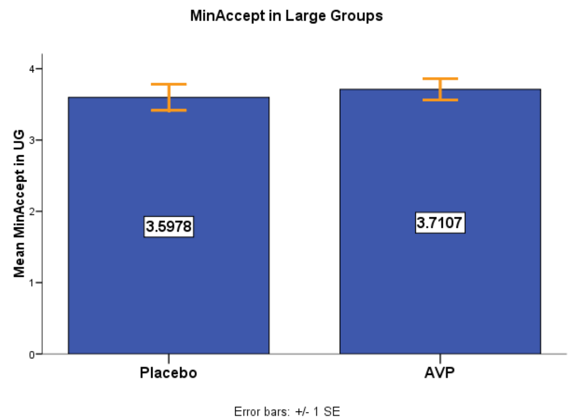

Figure 3.4 MinAccept in Large Groups.

There is no difference between AVP and placebo treatment groups' responses in LG. However, there is significant difference in the decisions of the subjects in the placebo treatment groups between the SG and LG (Mann-Whitney U-test p = 0.002) but not so in the AVP treatment (Mann-Whitney U-test p = 0.770). The response difference of the subjects in the placebo treatment group but not those in the AVP treatment group shows the adjustment that would be necessary given group-size changes but subjects in the AVP treatment groups appear to be inhibited from being able to make that change. They seem to behave more aggressively by guarding their own welfare. In SG the MinAccept is significantly higher on AVP than on placebo (\$3.909 vs. \$2.08) but in LG the difference is the opposite in direction, though not so pronounced (\$3.56 for AVP and \$3.96 for placebo). In small groups, the difference between the treatment groups is highly significant (Mann-Whitney U-test p = 0.004) but not in large groups (Mann-Whitney U-test p = 0.245). To be sure that these findings are not likely to be noise, the Chow-test was used to test the likelihood that SG and LG are distinct with respect to MinAccept (after adjustment of a heteroskedastic residual with weighted least squares, the Chow-test shows modest differences F = 2.17, p = 0.0788). After the results of the Chow-test, there is a likelihood that the differences in SG and LG with respect to the MinAccept might be noise.

Trust Game

In the TG we can see a similar phenomenon except that as the strategy of the game is different, the implication of the behavior is also different. As figure 3.5 shows below, the amount of money returned by DM2 demonstrates significant learning effects.

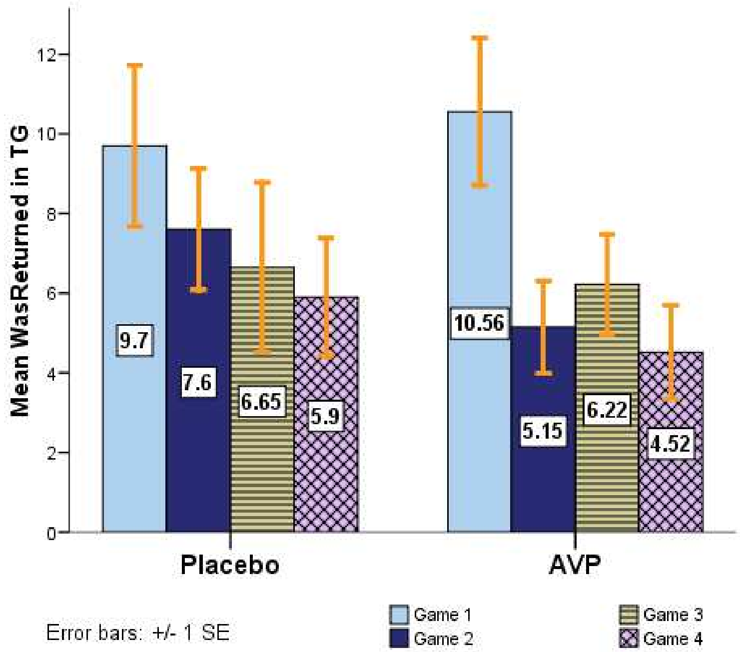

Figure 3.5 Learning effects are visible in the amount of money returned in 4 games

I used the following model for regression and the residuals, which had no learning effects, was used for further analysis in the TG:

$$WasReturned = a + b \cdot AmtSent + c \cdot Game1 + ... + e \cdot Game3 + f \cdot Small + \varepsilon$$
$$AmountSent = a + b \cdot Game1 + ... + c \cdot Game3 + d \cdot Small + \varepsilon \ .$$

I found that the residuals between SG and LG were significantly different with respect to AVP treatment between different sized groups (Mann-Whitney U-test WasReturned residual for SG p = 0.019 and LG p = 0.135 and for the AmtSent in SG p = 0.029 and in LG p = 0.841). As group size made a big difference, I split the dataset into two: SG and LG datasets, as before, and rechecked if learning effects were still present (Kruskal-Wallis for WasReturned in LG p = 0.003 and AmtReturned in LG p = 0.311; WasReturned in SG p = 0.500 and AmtSent in SG p = 0.944). The following two tables show the results of the regression in SG and LG with the dummies as shown above.

	AmtSent	WasRet	AVP	SG/LG	Games^	Const.
AmtSent	-	.149*** (.032)	-.038 (.476)	-1.46** (.633)	-1.72** (.682)	5.68*** (.573)
WasReturned	.727*** (.155)	-	-.837 (1.047)	4.06*** (1.393)	All***	6.19*** (1.48)
AmtSent SG	-	.016 (.059)	-2.5* (1.324)	-	.002*** (.817)	6.19*** (1.838)
WasReturned SG	.183 (.655)	-	-10.89** (4.213)	-	7.85 (5.234)	12.81*** (6.099)
AmtSent LG	-	.201*** (.041)	.092 (.517)	-	.789*** (.247)	3.37*** (.685)
WasReturned LG	.699*** (.141)	-	.853 (.963)	-	All (-) &***	5.08*** (1.314)

*** p < 0.01; ** p < 0.05; *p < 0.1 ^The game chosen is most conservative

Table 1 Regression results for the TG.

The regression analysis has three parts: combined group, SG, and LG. In the combined group, where there SG and LG are not separated, the results show that there is a significant interaction between the amount of money sent by DM1 and what was returned by DM2, but there are no AVP treatment effects.

The regression analysis results for SG show that the amount of money sent by DM1 did not influence the amount of money returned by DM2 but AVP had a significant negative influence on what DM2 returned. In LG the opposite is true; AVP had no significance but the amount of money sent by DM1 had a significant and positive effect on the amount of money DM2 returned. In LG DM1 was not influenced by AVP whereas in SG DM1 was affected by AVP. As previously used, here too the Chow-test was used to check if the differences between SG and LG are noise. The Chow-test results show for both the amount of money sent by DM1 and the amount returned by DM2 to be significantly different between the small and large groups (Chow-test for AmtSent $F = 6.07$, $p = 0.000$ and for WasReturned $F = 20.19$, $p = 0.000$).

Dictator Game

In investigating the DG, the control, I found that the amount of money sent in the DG was neither affected by AVP nor group-size, as hypothesized (Mann-Whitney U-test in SG, AVP vs. placebo $p = 0.125$; in LG AVP vs. placebo $p = 0.954$), although there is a definite visible trend toward implying that groups size and AVP might also have made a difference had the number of observations been large enough.

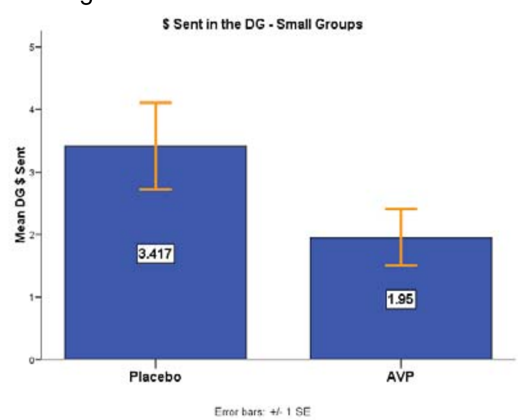

Figure 3.6 The amount of money sent in the DG in SG between treatment groups

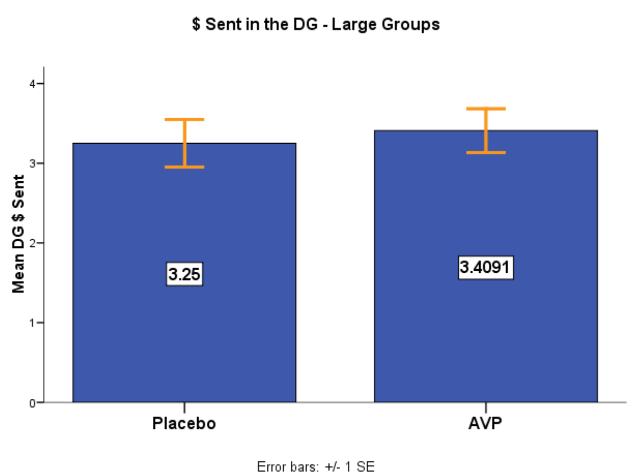

Figure 3.7 The amount of money sent in the DG in LG between treatment groups

The statistical result implies that AVP did not make subjects unaware of their decisions but that they consciously made whatever decisions they made. This also shows that the decision-making in the DG uses different neural substrates from the UG and the TG since the amount of money sent in the DG is neither affected by AVP or nor groups-size. However, running the Chow-test to double check if there is truly a difference between small and large groups, I find that there is a significant difference between groups (Chow-test F = 7.43, p = 0.000). As an inconsistent result with the other tests, this suggests that there might be some effects that would show up, given a larger observation base.

The Mechanism of Punishing in the UG

The following analysis continues based on the assumption that the results found so far are not noise and that both group-size dynamics and AVP treatment makes a difference in the amount of money sent or returned in the TG. Although test results show that there is no difference between AVP and placebo treatments in the combined small and large groups, it is worthwhile to investigate if there is some significant difference in the amount of money DM2 returned given the size of the amount of money DM1 sent. Do DM2s punish by returning significantly less if DM1 sent less than the average? In the combined group, the average amount of money DM1 sent is $6 and the average returned by DM2 is $7. How much money did DM2s return to DM1s who sent less than $6? There is no difference between the groups (Mann-Whitney U-test for reciprocation when more than average was sent p = 0.222 and for punishment when less than average amount of money was sent p = 0.546).

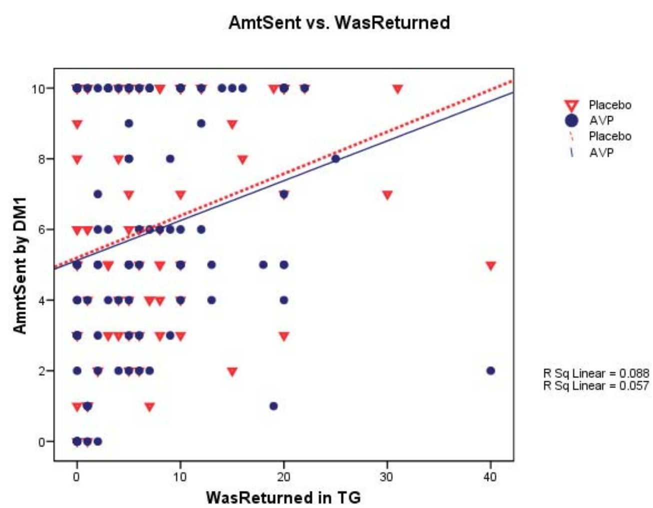

Figure 3.8 General trend of reciprocation in the TG

Interestingly, there is an unexpected trend when looking at the scatter plots of the relation between the amount of money sent and what was returned when the DM1 sent more than the average of $6 or less than that.

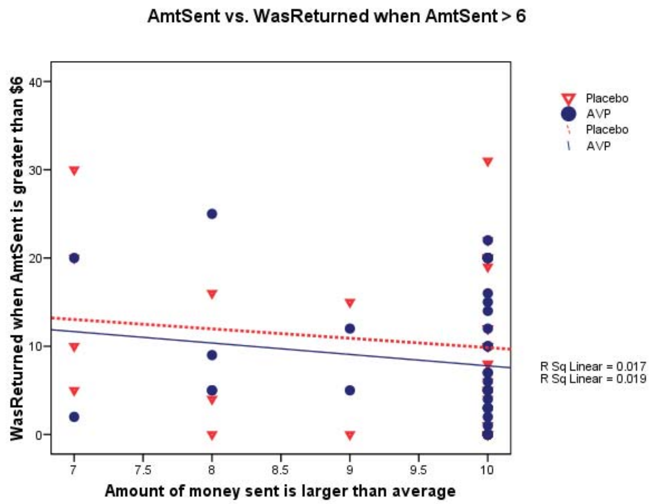

Figure 3.9 When DM1 sent more than the average, the more money was sent, the less was returned by both treatment groups—a negative relationship.

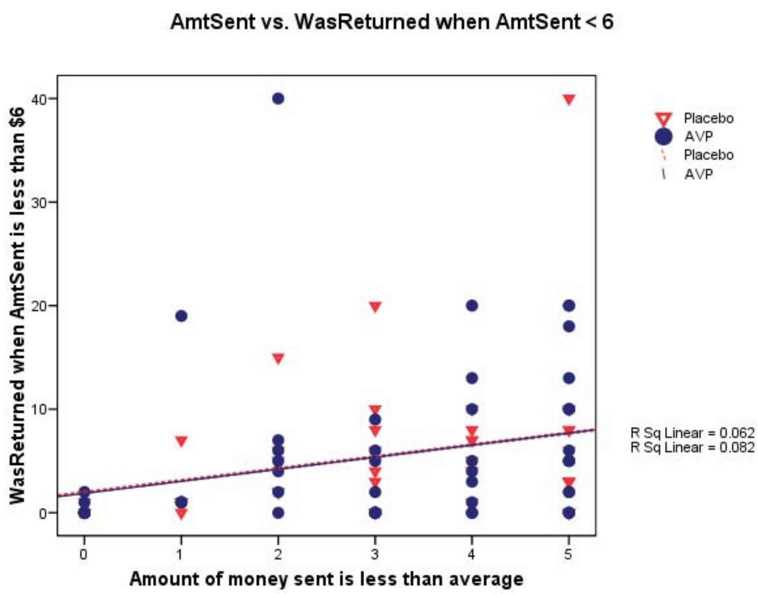

Figure 3.10 When the amount of money sent by DM1 is less than average, more money is returned by DM2 for more money sent by DM1 in both treatment groups nearly identically—a positive relationship.

To get a better understanding of the punishment mechanism used by our subjects in the UG, I calculated how DM2s responded to being sent less than or more than the average amount of money sent by DM1 in LG and SG between the AVP and placebo treatment groups in the UG. The average MinAccept in SG is \$3.22 and in LG \$3.73. As only dollar incremental amounts were possible to send, the two group-means, for the purpose of comparison, is \$3. I need to also note that since there is no feedback to DM2s about how much money DM1s sent to them, their decision to have high or low MinAccept is decided by DM2s based on their belief of the likelihood of receiving certain amount. Thus "punishing a low offer" implies that DM2 decided in advance that he will punish offers that are below a certain threshold. This threshold was significantly larger in SG for DM2s in the AVP treatment groups.

I checked to see how differently the AVP treatment groups treated those offers that were below \$3 or over \$4, ignoring the response to the actual mean. The analysis shows that there is a significant difference in the treatment of both those who send less than \$3 and those who send more than \$4 in the UG by DM2s in the SG (Mann-Whitney U-test p = 0.004 in SG for offers <\$3 and p = 0.005 in SG for offers >\$4) in SGs.

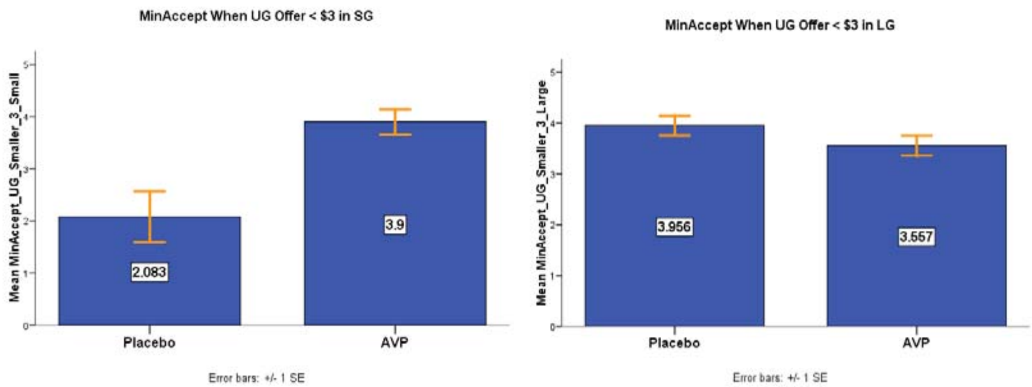

Figure 3.11 The AVP group is significantly more punishing in SG (left figure) than in LG (right figure) and the placebo significantly more forgiving in SG than in LG when the UG offer is less than \$3.

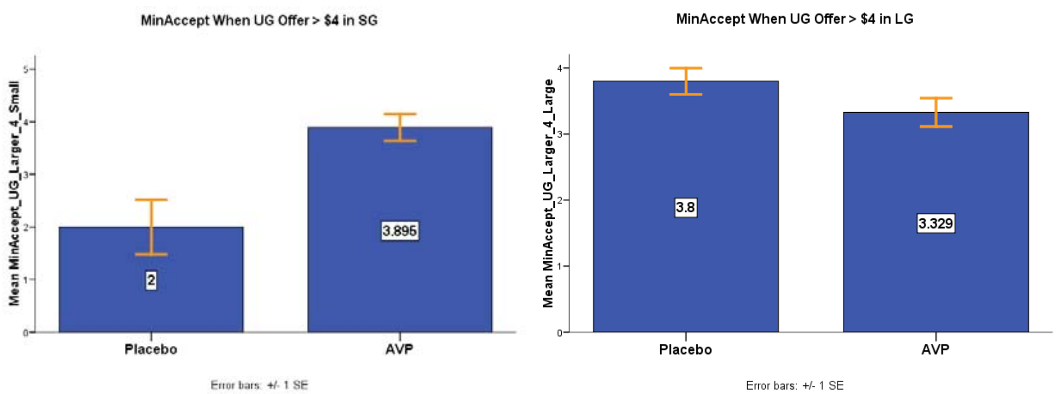

Figure 3.12 The AVP group is significantly more generous in SG (left figure) than in LG (right figure) and the placebo significantly more punishing in SG than in LG when the UG offer is larger than \$4.

A note of importance: in the UG, each subject stated his MinAccept without learning about the actual offer of DM1. As a result, the results capture pure AVP effects rather than additional emotion-driven effects, such as anger and spite that might be generated by small offers versus happiness when an offer is larger than expected. Therefore, what these results show represent strong indications that small groups behave differently from larger ones and that AVP is more functional in small groups than in larger ones. The evolutionary explanation of this might relate to reactive aggression with respect to kin-protection. The purpose of the two different size groups might signal different functions and large groups might necessitate OT release in order to allow for prosocial cooperative activities, which might override the administered AVP. The finding that AVP affects the punishing in the UG implies that such punishment is selfish in nature since AVP, as introduced before, is a hormone that activates in cases of for kin-protection and resource protection for the sake of kin.

Discussion

In this experiment we found that AVP influences the decision-making of subjects in small groups by making them punish more UG offers that are below the expected. AVP also makes subjects more generous when the offers received exceed the expected. The results also showed that there is a significant influence of group-size whose dynamics influence the decision-making of the subjects in the placebo group and that those on AVP are inhabited from such adjustment. AVP possibly inhibits OT release in small groups, which is an expected consequence of DM1 initiating a "trust signal" by sending a positive amount of money to DM2 (Paul J. Zak *et al.* 2004). Subjects on AVP are less trusting whereas the placebo treatment group does not seem to be influenced by group-size.

Searching to see if we had an exceptional sample of the student population at UCLA, I analyzed the surveys we asked them to fill out while waiting for the full effect of the AVP to be reached. One of these surveys measured if AVP had any influence on memory as the review of the literature suggested that AVP may improve social memory in humans (G. W. Bennett *et al.* 1997) as it appears to improve memory in mammals (Maria Malgorzata Winnicka, Konstanty Wisniewski 1999; Arne Dietrich *et al.* 2001; Richard J. Bodnar, Gad E. Klein 2005; Tomoaki Sato *et al.* 2004). Statistical analysis did not confirm that our subjects memory was affected by AVP; neither was the score they earned by answering correctly affected by AVP (Kruskal-Wallis test for each un-aggregated game varies from $p = 0.06$ to $p = 0.981$) nor the time it took them to complete the task (Kruskal-Wallis test varies from $p = 0.247$ to $p = 0.897$). Since the subjects filled out the surveys, including the memory test, only once, the results don't reflect aggregated observations. SG or LG also did not have any effect on the subjects memory (Mann-Whitney U-test $p = 0.234$ for memory scores and $p = 0.245$ for time to completion).

Consistency of the participants was evaluated using three survey questions (as described in Chapter 2): 32 participants (60%) responded consistently to the three survey questions and 22 inconsistently. Of the consistent ones, 15 were in the AVP and 18 in the placebo treatment groups. There were very slight significant associations between age and five variables, which is probably noise. Ethnicity showed very slight significance when ethnicity was white.

Tentative Conclusions

In this experiment we played the three games, UG, DG, and TG in only one order. We know from previous experiments that in the TG, DM1s who decide to trust and send some money to DM2, release the hormone oxytocin (OT) (Paul J. Zak *et al.* 2004) and also when OT is artificially administered to subjects who play the TG, they become more trusting and send substantially more money to DM2 in the TG (Michael Kosfeld *et al.* 2005b) and that OT influences the subjects in the UG and they become more generous. It is speculative to suggest that OT is released by playing the TG in quantities that exactly cancel out the affect of the administered AVP but it is known that OT and AVP have overlapping function, might influence each other's receptors or functions (C. Sue Carter 2007), and that administering OT after AVP in animals does wash out AVP effects (C. A. Pedersen, M. L. Boccia 2006).

In some animal studies it has been shown that OT and AVP influence the same behavior, particularly in males: sometimes the administration of OT causes aggression in males based on social dominance status (O. J. Bosch *et al.* 2005;T. R. Insel, R. D. Fernald 2004). In particular, a research addressed the issue of AVP and OT conflict, particularly at the AVP V1a receptor, questioning if OT suppresses the V1a receptor activity (C. A. Pedersen, M. L. Boccia 2006). In a future experiment, it would be valuable to repeat this experiment with randomized game order to see if the release of OT by playing the TG first modifies the effect of AVP and provides different results from when other games are played first. The games should be played in randomized order—six orders to be precise: UG/DG/TG, UG/YG/DG, DG/UG/TG, DG/TG/UG, TG/UG/DG, and TG/DG/UG. Any of these games may influence the subjects' decisions they make in the games that follow. By randomizing the order of the games, it is possible to isolate and remove such interference.

The results of the AVP experiment show that AVP might influences decision-making of subjects given the appropriate group-size dynamics but it is possible that, at least in some parts of the experiment, the results of the analysis reflect only noise. It would be necessary to run a new version of this experiment such that half of the experiments would work with small and half with large groups only.

In conclusion, much remains to be understood about the functions of hormones in our decision-making. In the following chapter I discuss future research opportunities that might shad light better on how our decisions are affected by who we are.

Chapter Four

Future Research

I found in my research with oxytocin (second chapter) that humans are more generous when OT is administered to them. In that experiment, while analyzing the surveys, I found that the subjects responded differently to questions of attachment, bonding, and trust, to strangers than to partner (kin) under the influence of oxytocin. As described in the previous chapters, we know much about OT; it is a neuropeptide that affects social behavior and the mechanisms underlying social behavior (Kristin M. Kramer *et al.* 2005; Alison B. Wismer Fries *et al.* 2005), such as trust (Michael Kosfeld *et al.* 2005b; Paul J. Zak *et al.* 2004), the ability to form social attachments (Kerstin Uvnäs-Moberg, Eva Björkstrand 1998; C. Sue Carter 1998), and the feeling of empathy toward strangers (Kerstin Uvnäs-Moberg, Maria Peterson 2005; Richard A. Depue, Jeannine V. Morrone-Strupinsky 2005). Oliver Williamson suggested that humans have two distinct types of trust-behaviors: one reserved for friends and family and the other, which is calculated risk rather than trust, is reserved for strangers (Oliver E. Williamson 1993).

In my experiment I found that only trust toward strangers was affected by oxytocin, while trust for a partner remained unaffected. Although this shows that humans do have trust toward strangers in economic exchanges, it does not conclusively prove or disprove that there are two types of trusts. As this was merely a serendipitous finding in an experiment that was designed for a different purpose, what is needed is an experiment designed specifically to confirm or deny this trust-difference finding. If the result of this serendipity is confirmed, finding the locations of these two types of trusts in the brain would be a fascinating experiment providing further research opportunity along this subject in a variety of ways.

Another finding of the experiment described in Chapter 2 was that OT appeared to have some influence over subjects' lack of feeling guilt. While this finding was also serendipitous, and therefore inconclusive, it showed that those on OT did not seem to feel guilty when they knew they did something wrong but those on placebo did. It would not be difficult to design an experiment to test whether OT does indeed mask the feeling of guilt, which, if shown to stand, could be extremely important in examining the OT connection to the "criminal mind."

Based on the results of experiments using economic games, recent literature suggests that subjects seem to accept the impression of fairness and often "pretend" to be reciprocators themselves to gain cooperation in circumstances where cooperation otherwise would fail (Michael P. Haselhuhn, Barbara A. Mellers 2005; John H. Kagel *et al.* 1996; Colin F. Camerer, Ernst Fehr 2006; Colin F. Camerer, Richard H. Thaler 1995). This leads to an exciting research area that I would like to pursue, in which I could separate the "fake" from the "real" social signal. Subjects would be playing economic games, such as the trust and ultimatum games, in the fMRI to identify the regions of hemodynamic response. Given information asymmetry, do all people fake? Is there a cultural norm of faking?

Another project of great interest was spurred by a comment made by Vernon Smith, in which he stated that each person has both self-regarding and other-regarding decision-making abilities but *chooses* to use each according to the requirements of the moment (Vernon L. Smith 1998a). This implies two things: firstly it suggests that if one chooses whether to be self-regarding or other-regarding, then "faking" other-regarding preferences according to the "requirements" might indeed place such "faking" into the cognitive domain. Secondly, it suggests that there is a continuum between behaving in a self-regarding or other-regarding manner, which, in turn, necessitates a tipping point. Where might such tipping point be? And, in fact, if I could find such tipping point, this would provide support to my previous research question of separating "fake" other-regarding behavior from the real one. If there is a continuum between self- and other-regarding behaviors, which behavior is representative of the mean? I propose that such tipping point would provide a “cultural norm marker” that could be used as an index for contract evaluation by firms that negotiate on international levels.

A project worthy of mention is an experiment designed to resolve the question whether humans are or are not consistent in their preferences. Numerous debates over the past twenty years have continued to fuel two camps with each side placing forth strong arguments in favor of one point or the other. The two chapters discussing the experiment with OT and AVP provide some indication that people are “inconsistent” in their preferences (relative to expected utility theory) when the external environment is unchanged (relative to one day to the next) but their “internal environment” is changed. This is pronounced, in particular, with respect to the Expected Utility Theory (EUT) which posits that each agent can rank-order his or her preferences. However, if an externally administered hormone is able to sway the preference of a person in one direction or the other, the question arises whether people are biologically incapable to be consistent—with respect to the axioms of the EUT. It is important to note that hormonal level-changes in the brain are naturally occurring throughout the day, thus an externally administered hormone is not necessarily that different from daily variation that occur naturally.

However, I think that it is too narrow to consider consistency or inconsistency with respect to a theory that leaves out changing environments, both external and internal—the EUT evokes the *ceteris paribus* command for all context and environment. It is, therefore, best if one looks for consistency outside of the EUT. I propose that human decision-making is based on a biological response to the environment and I would further propose that this response is consistent. To me it seem completely logical to suggest that hormonal variations initiate the “human heuristic” approach (rule of thumb) even subconsciously in order to responds appropriately to external environmental changes and stress. An experiment that is able to fix one of the two environments “enough” (inside the brain or outside the brain) and stimulate only specific cues might offer a better understanding of the issue of consistency.

In addition to human decision-making, I would like to also look for dangers associated with hormones that are often used indiscriminately by hospitals for enhancing the labor of expectant mothers. There is a potential for a disastrous outcome in the common practice of pregnant mothers receiving Pitocin (oxytocin) to induce labor. OT has become a star hormone in inducing labor because it reduces labor time to 24 hours; it has become a star hormone in microeconomics because it affects decision-making by making people more trusting (Michael Kosfeld *et al.* 2005b), and it has become a star hormone in macroeconomics because it affects the wealth of nations (Paul J. Zak, Stephen Knack 2001; Paul J. Zak, Ahlam Fakhar 2006). We now also understand how it affects the brains of infants as OT overload induces adaptation, shown to be the case so far with small mammals, when OT is given to animal mothers in labor (Karen L. Bales, C. Sue Carter 2003; C. Sue Carter 1998; C. Sue Carter 2003; Kristin M. Kramer *et al.* 2005). Adaptation induces the reduction of OT production and/or damages the receptors, thus the newborn vole (*Microtus ochrogaster*) is not able to produce/use enough OT later in life, causing serious problems. Infant voles that experienced externally provided OT in their mothers’ womb exhibit autistic-like (socially withdrawn) behavior. Furthermore, since OT facilitates milk-let-down in mothers for breastfeeding (in humans too), OT-bathed vole babies in the womb are not able to reproduce successfully at maturation (C. Sue Carter 2003). Should OT have similar effects in human babies’ brains, as my hypothesis suggests it does, research in this area will have significant policy implications.

Dedication

I dedicate this dissertation to my husband for all his support and patience and for not only enduring but actively participating in the hard work and joy of having my dream come true. Thank you Andy!

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This dissertation could not have been born without the support and help of my professor and friend Paul J. Zak. His incredible energy, his ability to focus on everything at once, and his insurmountable intellect provided a fantastic environment for my education and research. I would like to also thank him for the financial support for my experiments. I am indebted to Arthur Denzau and Thomas Borcherding for their guidance, support, and advice. Additionally I would like to thank the Center for Neuroeconomics Studies research assistants, my colleagues, for helping with my experiments.

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